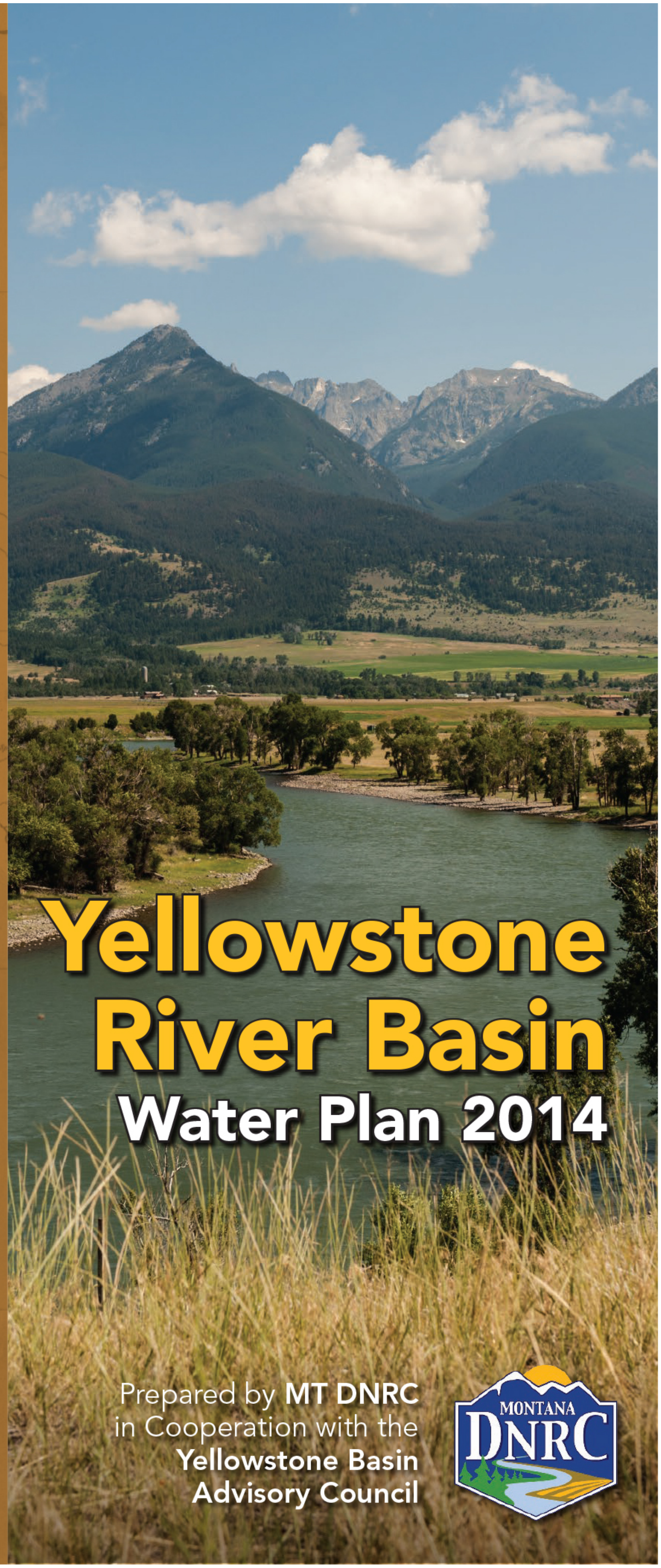

Yellowstone River Basin

Water Plan 2014

Prepared by **MT DNRC**
in Cooperation with the
Yellowstone Basin Advisory Council

MONTANA DNRC


MONTANA WATER SUPPLY INITIATIVE
YELLOWSTONE RIVER BASIN WATER PLAN

Contents


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I. EXECUTIVE SUMMARY

It is with the recognition of our dependence on clean, plentiful supplies of water that the Yellowstone Basin Plan is submitted. Its contents document a year-long examination by the Yellowstone Basin Advisory Council. Its purpose is to document the status of the Yellowstone's water resources, and propose a path forward in terms of how DNRC and other entities manage and protect Yellowstone water for the benefit of current and future generations. The recommendations within this document reflect the collective understanding and intent of a broad range of water users that share a common concern - *how do we ensure water availability now and in the future?*

As is evidenced by the degree of participation in the 2015 Montana Water Supply Initiative (MWSI), water users in the Yellowstone River basin are keenly aware of the link between water and their quality of life. Recent extended dry spells, such as the below average years of the 2000's, combined with the scientific and associated media attention on the potential effects of climate change, have heightened public interest in the management of the state's water. And whether you subscribe to climate change theory or not, the Yellowstone hydrologic record is replete with extended severe droughts (See Section IV-Water Resources).

With the potential for increasing demands and supply variability, the time is ripe to put Montana on a course toward a more sustainable water future, a course that provides the water necessary for existing and potential future uses necessary for economic growth. The guiding legal principles are in place: the Montana Constitution with its provisions for a clean and healthful environment, and the Montana Water Use Act with its provisions for allocation according to the prior appropriation doctrine ("first in time is first in right"). However, like so many complex resource stewardship challenges, a wide range of opinion exists about how to achieve the end goal of increasing water availability.

Basin Advisory Councils (BACs) and the Montana Water Supply Initiative (MWSI)

In 2013, under direction from the Montana Legislature, the DNRC launched the Montana Water Supply Initiative (MWSI) to work with citizens and community leaders to transform the current Montana State Water Plan into a dynamic guide to help residents and water managers in the state's major river basins: the Clark Fork and Kootenai, Yellowstone, Upper Missouri, and Lower Missouri. The Legislature directed DNRC to update the State Water Plan (SWP) and submit the results to the 2015 Legislative Session.

The 2009 Montana Legislature modified the state's water planning legislation (MCA 85-1-203) mandating that, "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. 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 combinations of uses." See: http://leg.mt.gov/bills/mca/85/1/85-1-203.htm

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.

PURPOSES OF THE BASIN ADVISORY COUNCILS

The Basin Advisory Councils (BACs) are to:

A. Provide input and recommendations to DNRC as required by 85-1-203(3);

B. Serve as advisors to DNRC and provide an avenue of communication and discourse between the various water interests within the basin;

C. Evaluate strategies, studies, and proposed actions for improving the understanding management and conservation of water resources in the basin and,

D. Act in an advisory capacity to the DNRC for purposes of the basin planning process.

ROLE OF DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION

Ground rules were established that specified the roles of the BACs and DNRC. See: http://dnrc.mt.gov/mwsi. DNRC provided technical information and advice and acted as the project fiscal agent. For the Yellowstone River Basin (YRB) DNRC contracted with Montana State University-Billings, and Beck Consulting of Red Lodge, Montana for coordination and meeting facilitation during the scoping and recommendation development phases of the project. Both contractors produced reports that detail the MWSI water planning process for the YRB (see http://dnrc.mt.gov/mwsi).

The Yellowstone River Basin Advisory Council 2013-2015

The Yellowstone Basin Advisory Council (YBAC) consists of 20 representatives assembled from key water interests within the basin: agriculture, conservation, industry, municipal, recreation and tribal. The work of the YBAC culminating in the recommendations for the SWP was carried out in three phases:

A. Public Scoping: YBAC selection, public scoping, and determination of priority issues;

B. Information Transfer: presentations by practitioners and subject matter experts on topics related to the priority issues;

C. Recommendation Development: draft recommendations, conduct public review process, prepare and publish final recommendation report.

In addition to the specific recommendations contained in Chapter IX of this document, detailed descriptions of the methods and results of the scoping and recommendation development processes are contained in reports available at: http://dnrc.mt.gov/mwsi

MAJOR FINDINGS OF THE YELLOWSTONE BASIN ADVISORY COUNCIL SCOPING PROCESS

In sum, the 148 members of the public that engaged in the scoping effort identified a wide variety of water related issues that were grouped into 28 primary concerns by the MSU-Billings team assisting the YBAC. The YBAC then prioritized these concerns into eight primary issue areas. In order to develop a realistic scope of work for recommendation development, the YBAC deliberated and discussed the 28 issue categories and questions from the scoping efforts, built off the public's input, and prioritized issues to address in the next phases of the MWSI. The YBAC identified the following nine priority issue statements:

DROUGHT READINESS: Numerous extended dry periods are documented in the Yellowstone hydrologic record. Water availability and drought preparedness are motivating factors in any water resource sustainability strategy. Many tools and policies are available, including conservation, to assist with effective water allocation that maintains economic viability and preserves resource values during drought (see Water Information, Watershed Planning, and Water Administration/Beneficial Use).

WATER INFORMATION: The adequacy of existing water information, along with its availability, and ease of access to water users, water managers, and the public is an issue. Sufficient water data needs to be collected and made available so that all relevant water information pertaining to a water body can be readily accessed and used to make informed decisions.

INTEGRATED WATER QUALITY AND QUANTITY MANAGEMENT: Water use and water quality are linked. Every use of water affects its quality and as water consumption increases or the characteristics of the supply change, new and alternative uses can be affected. Water quality is an important issue in all areas of the Yellowstone River basin and influences beneficial uses.

WATER ADMINISTRATION AND BENEFICIAL USE: Enabling fairness under Montana's water law is a significant issue in the Yellowstone Basin. Uncertainty is created by the large number of unused claims in the DNRC water rights system and senior users are sometimes unable to meet their water right due to misappropriation by other users. Any strategy to meet future water demand and put water to beneficial use needs to include examination of Montana's water right system so as to identify opportunities to maximize administrative efficiency and ensure proper monitoring and enforcement of water rights.

WATERSHED PLANNING: Many water resource problems are watershed-specific and their solution requires a collaborative stakeholder approach within small- to medium-sized watersheds within the Yellowstone River basin, while other issues require a basin-wide approach. The need for planning and technical services, and access to information to develop and implement watershed plans, is expected to increase as demand for water increases. Existing funding mechanisms and personnel to support locally-led watershed planning are presently insufficient to meet current and projected demand.

GROUNDWATER/SURFACE WATER NEXUS: Ground and surface water are linked, often in complex interactions that can only be characterized through site-specific long-term measurement and monitoring projects. Although groundwater usage in relation to surface water is relatively minor in the Yellowstone River basin, localized problems exist, particularly in areas impacted by land use changes or conversion from flood to sprinkler irrigation.

INSTREAM FLOW MAINTENANCE**:** Despite the lack of on-stream main stem storage reservoirs, the natural hydrology of the Yellowstone River has been significantly altered by present-day levels of development. Instream flow maintenance pertains to maintenance of a stream's complete hydrologic regime. Maintenance of instream flows is a significant issue, not only on the main stem Yellowstone River and its larger tributaries, but also on smaller tributaries necessary for the functionality of the river system.

WATER STORAGE: Water storage is an important part of integrated water management in the Yellowstone River Basin. However, traditional storage projects (dams and reservoirs) are expensive to plan, construct, manage, and maintain. In addition to construction of new storage, alternatives such as the prioritization of uses for water stored within existing reservoirs, maintenance of storage facilities, and modification of existing projects are important tools to mitigate effects of water supply variability. Managing stream and wetland systems to enhance natural channel and floodplain storage can augment structural measures by reconnecting streams to their floodplain, protecting wetlands, and encouraging healthy riparian vegetation.

FUNDING: The legislature directed that DNRC update the MWSI. In order to implement the statewide water plan, funding is required.

SUMMARY OF THE YELLOWSTONE BASIN ADVISORY COUNCIL RECOMMENDATIONS

Several overarching themes surfaced as the YBAC developed and discussed the preliminary recommendations:

1. The recommendations should not threaten the prior appropriation doctrine.
2. The recommendations should be stated in simple, non-technical terms.
3. There should not be redundancy of recommendations where issues overlap, for emphasis, or for any other reason.
4. YBAC wanted to and did consider water issues within their charge regardless of which state agency has the lead for a particular issue. For example, water quality was important to the YBAC although the lead for this issue is the Montana DEQ rather than the DNRC.
5. The YBAC believes that state agencies should work closely together to benefit water users and Montanans.
6. The YBAC was conscious of the financial implications of recommending anything new or adding a level of effort to on-going work.

The issue statements, combined with the overarching themes stated above resulted in the following recommendations that were used to inform the development of the 2015 State Water Plan. For brevity, only the objectives are stated here. More detail can be found in Chapter IX - Findings and Recommendations.

The Yellowstone Basin Advisory Council (YBAC) recognizes that implementation of these recommendations represents a significant investment in Montana's water future. The YBAC anticipates that they will serve as an indicator of public sentiment to federal, state and local, and private entities engaged in the planning, design, construction, and operation of water resource conservation and development projects in the Yellowstone Basin and for the rest of Montana. In particular, it is the YBAC's intent that the recommendations contained herein will guide the state's programs with respect to water management and development over the next 20 years, and in so doing will help all users secure access to a more certain water future.

DROUGHT READINESS:

A. Support and expand Montana's existing drought readiness efforts at local levels.

1. Expand the capability of the Governor's Drought and Water Supply Committee through implementation of information systems to support drought monitoring and availability of water information to water users and watershed groups for purposes of watershed planning;
2. Strengthen support and funding for programs, including Montana university and college programs--including the Montana Climate Office--involved in drought monitoring and forecasting;
3. Establish a statewide task force to coordinate water and climate information in an effort to eliminate duplication;
4. Develop adequate funding sources and incentives for mitigation of drought impacts for all water users.

B. Strengthen existing policies and statutes necessary for effective management of water resources.

1. Recommend changes, if necessary, to statutes and DNRC policies regarding water planning and management to improve the availability and distribution of water during droughts.
2. Recommend changes, if necessary, to statutes and DNRC policies that encourage conservation of water for all water uses and provide incentives for implementation of conservation measures.

C. Provide tools (policies and legislation) for temporary water-supply management during extended droughts. (The implementation items below would require assurances that the water-right holders' original entitlement and priority date remain unaffected, once the temporary use terminates):

1. Explore the feasibility of water banks.

2. During a declared drought emergency, develop water-use permits under an expedited process—drought permits would be limited to replacement of water not available under a permanent water right.
3. Develop temporary emergency water-use permits that include changes in type of use (including instream flow), place of use or point of diversion of an existing water right.

Water Information:

A. Education and Outreach. Provide adequate education and outreach to ensure water user understanding of Montana water right law, hydrologic principles, water commissioner competency, and uniform enforcement of water right decrees.

1. Prepare an Education and Outreach Plan that examines the existing programs and curriculum offered by DNRC and the Montana Watercourse for water-related training and education to determine the need for and costs associated with expanding these programs.

B. Water Information System. Improve Montana's Water Information System to allow better access to water supply and availability information and promote an integrated approach to water resource management.

1. Upgrade the accuracy of Montana's Spatial Data Infrastructure (MSDI) Hydrography Framework Layer for purposes of organizing and distributing water information such as:
   a. Dam and reservoir mapping,
   b. Aquatic habitat information,
   c. Water right diversions,
   d. Water quality data and discharge permits,
   e. Wetlands data,
   f. Floodplains, Riparian Zones and Channel Migration Zones.
2. Invest in analytical tools that provide basic hydrologic information on which to base management decisions by:

a. Conducting a Yellowstone River Basin Water Availability Assessment using a water availability model with updated software and inputs based on known factors such as decrees, compacts, the Yellowstone water reservations, historic stream gauge records, and updated water use estimates to determine the effect of increased water use and climate variability on Yellowstone water users, and
   b. Continuing development of StreamStats - an interactive, Web-based map application for providing streamflow statistics, such as the 100-year flood and the 7-day, 10-year low flow on streams and rivers with limited hydrologic information.

Integrated Water Quality and Quantity Management:

A. State Management of Water Quality in Water Quantity Allocation. DNRC and DEQ should determine the best administrative and organizational procedures to assure coordination and carrying out current law and regulations related to:

1. Changes in water quality that would adversely affect the ability of an existing appropriator to exercise his/her water right.
2. Changes in water quality that would make a water body unfit for supporting beneficial uses.
3. Changes in the wetland and riparian conditions necessary to sustain water quality.

4. Changes in water quality or quantity that would inhibit the ability of existing discharge permit holders to satisfy effluent limitations.
5. Maintain consideration of current and future flow in authorizing point source discharges.
6. Continue assessment of state waters for flow-related, beneficial use impairments.
7. Provide financial and technical support for activities designed to restore water quality in waters that currently do not support their beneficial uses.

B. <u>Support Activities and Programs to Benefit Both Water Quantity and Water Quality</u>.

1. Maintain funding for improving and protecting water quality using best management practices at all levels of implementation. Promote Integrated Water Resource Management by improving coordination among state and federal agencies, tribes, local watershed groups, and the public.

WATER ADMINISTRATION AND BENEFICIAL USE

A. <u>Water Right Adjudication Process</u>.

1. Maintain necessary water right claims examination services provided by the DNRC in support of the Montana Water Court.

B. <u>Abandoned (Orphan) Water Rights.</u>

1. Provide clarity through legislation to the administrative and water court processes used to identify abandoned and overstated water rights.

C. <u>Water Right Enforcement</u>. Ensure proper measurement and distribution of water under decree.

1. Enact legislation that allows water right holders to permanently establish enforcement projects through an administrative process, in addition to the legal process (filing suit in district court.)
2. Enact legislation that grants DNRC authority to directly enforce against illegal water use, including the imposition of penalties substantial enough to discourage such use.
3. Develop a method for disseminating information related to illegal water use complaints.
4. Maintain a water rights change process that requires applicants to accurately identify and describe historic use.

D. <u>Measurement, Monitoring and Assessment</u>. Require measurement and increase monitoring so that it is sufficient to understand water supply and use, enforce water right decrees and compacts, and to better understand the relationship between water quality and quantity.

1. Maintain the existing stream gauge network operated by the USGS for key main stem and tributary gauges via the USGS/DNRC Cooperative Agreement Program.
2. Institute a telemetered (real-time) stream gauge program operated by DNRC/MBMG.
3. Strengthen the capability to conduct an inventory of consumptive and non-consumptive uses.
   c. a. Develop the capability to measure agricultural water use using remote sensing, compare results of pilot studies to previous methods, and evaluate the overall cost-effectiveness of using remote sensing to measure water use.
   d. b. Require all users to measure at or near the point of diversion from the river or stream.
4. Provide assistance to water users to measure water at or near the point of diversion from a stream.
   - Offer a tax credit for the cost of installation.
   - Expand the DNRC Irrigation Development Program to provide grant dollars to pay costs.

- Facilitate the installation of measurement devices on development of Renewable Resource Grant applications for large volume ditches.

5. Knowing that these recommendations will incur costs, encourage multiple party collaborations and partnerships that yield creative funding mechanisms to pay for them.

WATERSHED PLANNING:

A. Resolve Basin-Wide Water Management Issues**.** Increase interaction and communication between water users, watershed groups, technical specialists, policy-makers, and water management agencies at all levels of government.

1. Continue to fund a basin-wide stakeholder group (such as the Yellowstone BAC). The purpose of the BAC would be to review progress on recommendations developed during the 2013/2014 biennium, advise DNRC on future water resource management priorities, and serve as a forum on basin-wide water-related issues.
2. Expand the scope of this group to include water quality, instream flow, groundwater, funding amounts and sources, and other related issues.

B. Resolve Watershed-Scale Water Management Issues. Increase interaction and communication between watershed stakeholders.

1. Use existing and potential funding mechanisms to provide technical and financial support to collaborative watershed groups in order to support recommendations in this plan.

GROUNDWATER/SURFACE WATER NEXUS:

A. Groundwater Measurement, Monitoring and Assessment. Obtain information sufficient to understand the potential consequences of land use change on ground and surface water resources.

1. Continue and, if necessary, expand the Montana Bureau of Mines and Geology groundwater monitoring and assessment programs.

B. Groundwater/Surface Water Interaction. Obtain information sufficient to understand the localized effects of groundwater/surface water interaction.

1. Establish a surface water assessment program jointly operated by DNRC and MBMG to investigate the interaction between groundwater and surface water at sub-basin scales.
2. The legislature should review and make any changes in statutes necessary to optimize use of surface water and groundwater resources.

C. Groundwater Conservation. Conserve groundwater resources in the Yellowstone River basin.

1. Encourage local jurisdictions (i.e. counties, cities and conservation districts) to identify the hydrologic effects of land use change.
2. Encourage landowners to reduce the amount of discharge from uncontrolled flowing wells in the lower Yellowstone and Powder River basins by proper winterization and installation of discharge control valves using a combination of DNRC-Conservation and Resource Development Division (CARDD), private grant funds, NRCS grant funds, and landowner in-kind services to install and operate.

INSTREAM FLOW MAINTENANCE:

A. Provide specific "Change in Use" mechanisms that allow and incentivize users to assist in maintaining instream flows without compromising their ability to use water or fundamental water right. Usage of existing tools, such as temporary and permanent changes to instream flow, should be expanded and promoted to protect instream flows within the prior appropriation framework.

B. Improve recognition of the surface water/groundwater nexus. Recognizing the hydrologic interconnectivity between groundwater and surface water, and affirming the need to protect instream flows, the waters of the basin should be better managed as an interconnected system.

C. Impact of future water development. In the context of existing and future development demands, the ability of the existing water supply to meet instream flow rights must be considered in approving new water developments (see B.2.a - Water Availability Assessment under Water Information).

D. Yellowstone Water Reservation Review Process. The water reservation review process established by the Board of Natural Resources and Conservation (now DNRC) should be implemented for all Yellowstone Water Reservations to determine whether or not the objectives of the individual reservations are being met and, if necessary, whether individual reservants have prepared water conservation and drought contingency plans as required by the Order of the Board.

E. Maintain an intact hydrologic regime. Manage river and stream flows in ways that avoid threats to the long-term health or survival of native species and implement practices that maintain or restore indigenous ecological communities, processes and functions.

F. Reservoir Management. Procedures to maintain instream flows should be developed with attention to the effects of new and existing dams on sediment transport, water temperature and the hydrologic regime. Strategies for water releases and sediment management should minimize the negative effects to riverine processes below the dam.

G. Longitudinal Connectivity. Procedures to maintain instream flows should recognize and document the importance of connectivity within stream systems, and efforts should be made to restore connectivity where needed by modifying in-channel barriers.

H. Drought Planning. Drought planning efforts within the Yellowstone Basin must include the development of legal, physical, and management mechanisms or plans to implement water conservation during drought periods to protect essential instream flows.

I. Channel Maintenance. Recognizing lateral migration processes as important, efforts to maintain instream flows should include provisions for retaining or reestablishing alluvial channel form and function with associated biological communities.

J. Continued Study and Monitoring. As the science of instream flow advances and more field data is collected, evaluation of instream flow needs must be ongoing. Monitoring riverine resource responses to instream flow prescriptions is a fundamental component of effective instream flow maintenance.

WATER STORAGE:

A. Prioritize New Projects. Affirm the use of criteria contained in the Montana Water Storage Prioritization Policy (MCA §85-1-704 (2)(a) through (2)(j)) as applied to the prioritization of new storage projects. Enhancing alluvial aquifer recharge via wetland and riparian zone improvement projects should also be considered as a means for reducing flow variability and maintaining the natural hydrologic regime for streams and rivers in the Yellowstone basin.

B. Maintain Existing Storage Projects. Affirm the use of criteria contained in the Montana Water Storage Prioritization Policy (MCA §85-1-704 (3)(a) through (3)(c)) as applied to setting priorities among storage rehabilitation projects.

C. Allocation of State Funds for Storage Projects. Affirm the use of criteria contained in the Montana Water Storage Prioritization Policy (MCA §85-1-704 (4)(a) through (4)(c)) as applied to setting budget priorities among new storage construction and rehabilitation projects.

D. Water Storage Financing. The State of Montana should focus resources on understanding, coordinating, and improving funding programs for water storage development, operation, maintenance, and rehabilitation.

FUNDING:

A. Revenue Sources: Look for revenue from new and existing sources.

1. Look for revenue sources from all those who benefit from access to state water resources (including recreationists, irrigators, municipalities, water-rights holders, etc.)
2. Look for revenue from existing funding sources (such as the Resource Indemnity Trust and other programs for example).

OPPORTUNITIES FOR RESEARCH AND INVESTMENT

A central theme that underpins the YBAC's recommendations is the desire to improve our understanding of water availability for all uses in the Yellowstone River Basin—at a scale that provides useful information to local water users. The ability to protect existing water rights, and develop new water resources, depends on an actionable understanding of water availability. The Yellowstone River basin is geographically extensive, with much of the water supplied by the western, high-elevation mountain areas—most of which are located in Wyoming. The Yellowstone Basin is also home to a wide variety of water uses, including irrigated agriculture, municipal and domestic water use, industrial and recreational uses—which during low-water conditions, often during droughts, compete for water. Yellowstone River water users include farmers and ranchers, public water supply systems, energy producers, and a unique riverine ecosystem that sustains a prized fishery and a valuable recreation/ tourism industry.

However, a number of uncertainties haunt the current understanding of physical and legal water availability in the Yellowstone River Basin. For example, partial water budgets (pie charts) presented in Chapter IV of this report are based on limited information that contain significant uncertainty: estimates of consumptive useare based on an analysis of a single representative water year; estimates of water withdrawal and consumptive use are estimated on an average annual basis that does not account for monthly and year-to-year variation; the role of reservoir storage and return flows, and the role of precipitation and consumptive use by natural vegetation (forests, stream-side vegetation) are not included. Further uncertainties include the lack of direct measurement of how much water is withdrawn and consumed by most uses of water, with irrigation being the most significant use. The effects of Wyoming's use and storage of water are not included. These uncertainties make it difficult to integrate our physical understanding of water production within the legal framework of water rights, for all uses, including instream flows and Tribal Compacts. Collectively these limitations hinder effective water management and development in the basin. Many of the YBAC's recommendations are aimed at reducing these uncertainties so as to improve basin-wide water utilization.

STATE WATER-USER PROFILE

Tom Harmon

WRITTEN BY AL KESSELHEIM, PHOTOS BY THOMAS LEE

HARVESTING A WILD RIVER'S TREASURE

"You never know what sorts of strange stuff you'll find in that river," Tom Harmon says. He is standing in his rock shop, surrounded by grinders and saws and polishers, piles of rock in various stages of preparation. He wears a blue work apron, glasses. In his rough, weathered hand he holds a 'blue agate.'

"In a lifetime of walking the gravel bars, this is only the second really blue one I've found," he says.

"Living down here, we see that river shift and change, islands move, gravel bars come and go. It's a very dynamic thing. We notice when things happen, and we know where to go and look."

Harmon grew up around Sidney. Walking the Yellowstone riverbed, looking for stuff, has been a lifelong occupation. Because the Yellowstone is a free-flowing river, punctuated only rarely with diversion dams, the river acts fairly naturally. That is to say that it floods regularly, that log jams form on islands, that ice scours the river bottom at spring break up, that cottonwood groves continue to flourish. Most important, to Harmon, the river keeps working its bed, revealing its treasures.

"When I was a kid I used to hunt for buffalo bones with a friend from Crane," he says. "We didn't know much about agates back then."

He never expected that his childhood appetite for river treasure would turn into his life's work, and his family business.

"I guess I must have a little prospector blood," he says.

After high school, Harmon went to school to be a mechanic and then got a job in a garage. On weekends he'd go to the river, picking rock with his father-in-law or his dad, or, often as not, alone.

"I started selling some of the rock I was finding. After a while I realized that I was making more money picking rock on weekends than I was at the shop all week," he remembers. "I talked to my wife about making the leap, going into the agate business." That moment of truth was some fifty years ago.

Harmon educated himself. His natural curiosity went hand in hand with his "prospector blood." He has become an expert on the Lewis and Clark Expedition, and has written several books covering history and geology. He can talk knowledgably about the Flaxville gravel beds, fluvial geology, local Indian battles, or steamboat lore. But his passion for everything agate runs as deep and strong as the river he searches.

Harmon and his family built the agate business slowly. He began traveling to rock and gem shows. He and his wife lived out of a station wagon, then a VW bus, learned the business by rubbing elbows with other rock hounds. Gradually Harmon learned how to polish and work his rocks into pieces of art.

"I look over each agate very carefully," he says. "I study the cracks, the color, the shape, and patterns. I start grinding away the flaws. The rocks expose themselves and I just try to go with that. When I reveal what I see as the beauty, I stop."

Lying around his workshop is the evidence of that process. Some are fluted and shaped, sculpted. Others are simply polished. Many are still rough, full of potential.

Harmon opened a rock shop in a blue building along Highway 16 in Savage. There he has developed a museum-slash-store brimming with the products of the Yellowstone River and its tributaries, including a massive 40.5-pound agate from Rosebud Creek. All of it a result of his simple, abiding passion for walking the lonely gravels, head down, eyes probing for the dull possibilities in the load carried by powerful currents. It is that obsession with the river, and what it carries, that keeps the whole enterprise going.

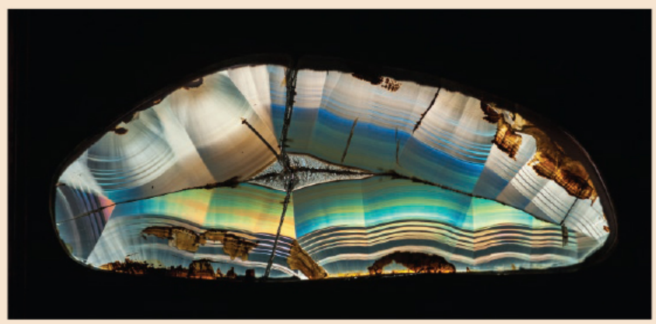
"Every spring, after the ice goes in April and May, I walk the gravel," Harmon says. "Then again after the river drops, in late July. I keep walking until winter stops me."

His daughter now runs the rock shop. His son has become a jeweler, fashioning the agates into earrings and pendants and pins. Harmon's boyhood appetite for strolling the river for treasure has evolved into a two-generation family enterprise.

Before we leave his workshop, Harmon beckons me over to the main house. "I've got something to show you," he says, and I have the feeling that not every visitor gets this treat. He takes me downstairs and turns on the lights in his display room.

There, spread out in cases, are the finished products he treasures most. Moss agates polished and worked into abstract sculpture, stunning jewelry, 'tube agates,' thin slabs of his latest passion—agates he calls Rainbow Iris, because of the prismatic effect of light in the sliced stones.

"I don't know what else I'd do," he says, surrounded by the glimmering gems. "I love going to that river. I always think that the next one I find will be the best ever." ■



"You never know what sorts of strange stuff you'll find in that river."

—Tom Harmon

II. Introduction

The Yellowstone River basin in Montana is blessed by a high quality natural environment, one that provides abundant fresh water for a variety of uses. Water, arguably our most precious natural resource, is closely tied to the Yellowstone basin economy given its heavy reliance on water-based economic sectors that are often in conflict. And despite the fact that the Yellowstone Basin in Montana generates more water within its borders than it uses, when a prolonged drought occurs, everyone suffers either direct or indirect economic consequences, or both.

At the time of this writing, 2014 has been a banner water year for the Yellowstone River Basin in Montana. The basin has been blessed with above average precipitation and a slow, sustained runoff of an above average mountain snowpack. This year the basin's rivers, streams and reservoirs are able to provide the water necessary to satisfy both consumptive and non-consumptive uses across the basin. However, as one Yellowstone sage remarked: "no matter the water year, we're just 10 hot days away from a drought". This is particularly true for irrigated agriculture where many users may depend on return flows from upstream flood irrigators to satisfy their rights. Similarly, instream flow advocates remain vigilant knowing that during low-flow periods, non-consumptive uses such as habitat, fisheries, tourism and hydropower can be adversely affected by consumptive uses operating outside established priority dates.

Statutory Authority for Water Planning

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 through their basin plans.

History of Water Planning in MT

Initial efforts at water resources planning in Montana centered on the development of irrigated agriculture to promote settlement. In the 1920's, 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.

Between 1934 and 1960, the Montana Water Conservation 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, Board actions created 438,017 acre-feet of storage and developed 405,582 acres of irrigated land. 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.

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 1943 and 1965, the Montana Water Conservation Board and the State Engineer's office developed comprehensive *Water Resource Surveys* for most of the counties in the Yellowstone River Basin. These surveys were developed from court house records, individual contacts, state and federal agency data, field surveys and aerial photographs. They contain an historic summary of the settlement, water use and survey maps of 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. These water resource surveys remain a valuable tool for characterizing and understanding the communities and water distribution systems in Montana's portion of the Yellowstone River Basin.

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 financial assistance. While these plans produced 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 that provided a forum for all affected parties, including those affected by, but without jurisdictional responsibility, to collaboratively work together on resolving water management issues. This approach included the formation of a State Water Plan Advisory Council and issue-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.

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

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

Yellowstone Basin Water Planning History

DROUGHT AND FLOODS COMBINE TO SET THE STAGE

The 19th and early 20th century history of water planning in the Yellowstone Basin is essentially a history of national politics surrounding settlement of the American West. Large river basin planning emerged post-World War II after decades of political struggle over which federal entity would oversee development. In the Missouri River basin (which includes the Yellowstone River basin), politics and the drought of the 1930's combined with the great flood of 1943 to set the political stage: The result: the Flood Control Act of 1944, with its Pick-Sloan Plan and O'Mahoney-Milliken Amendment. This legislation was significant to Montana and other upstream states in the Missouri basin because it codified protection for future increases in water usage in the upper portions of the basin like the Yellowstone River basin, and it gave the states some control with regard to federal water development. In the Yellowstone, a wide variety of planning efforts aimed at estimating the water development potential of the basin and assessing the impacts of such development on existing beneficial uses ensued.

FEDERAL PLANNING IN THE 1960'S

Some of these studies, such as the Comprehensive Framework Study (1967) produced by the Missouri River Basin Interagency Committee, were federal endeavors intended to estimate future water demand basin-wide and propose development projects under the goal of the Pick-Sloan Plan: *"secure the maximum benefits for flood control, irrigation, navigation, power, domestic and sanitary purpose, wildlife and recreation."* Others, such as the Wind, Bighorn, Clarks Fork Type IV Study (1974) or the Wild and Scenic River Study (1975), sought to assess the effects of an individual project such as a new Billings water supply system, or determine eligibility for programs operated by the U.S. Department of Agriculture. Once the Montana Water Resources Act of 1967 provided authority for development of a state water plan, DNRC began to develop and evolve a water planning strategy at the state level that emphasized economic development, conservation, and utilization of land and water resources.

FEDERAL PLANNING IN THE 1970'S

In 1975, as a result of concerns regarding expanded coal and irrigation development, DNRC produced the Yellowstone River Basin Water Resources Situation Report, which concluded that the basin did not have enough water to satisfy all existing uses, reservation requests, and projected demands. Two large federally-sponsored interdisciplinary studies ensued: the *Yellowstone Level B Study* (1977) and the *Yellowstone Impact Study* (1979). The *Yellowstone Level B Study* was a reconnaissance-level evaluation of water and related land resources for the Yellowstone River Basin and Adjacent Coal Area. This federally funded and managed study identified a wide variety of development proposals: new reservoirs, irrigation infrastructure, highway improvements, land treatments, wild and scenic river designations, etc. and attempted to assess their efficacy in achieving national economic development goals using a cost versus benefit approach.

Happening almost concurrently with the *Yellowstone Level B Study* was *the Yellowstone Impact Study*. Funded by the Old West Regional Commission and managed by DNRC, the study was a manifestation of a growing concern for water availability in the Yellowstone. Passage of the Montana Water Use Act of 1973, which among other things mandated adjudication of existing water rights and made possible the reservation of water for future beneficial use, was followed by the Montana Water Moratorium Act of 1974, which delayed actions on major applications for Yellowstone Basin water for three years. That period was later extended by legislative and court action and expired in December of 1978 when the Board of Natural Resources and Conservation acted on the received water reservation applications.

Citing a need to examine the individual and cumulative impacts of future water development, DNRC took advantage of the moratorium to study the basin's water and related land resources, as well as existing and future need for the basin's water. The study concluded that the Yellowstone mainstem and the Bighorn River would be able to meet even the demands of high-level development, although summer and fall flows would be extremely low in the mainstem as a result. The study also concluded that neither the Tongue nor the Powder rivers would be able to supply the water demanded of them under the high-level development scenario.

EVENTS SURROUNDING THE 1996 AND 1997 FLOODS

It wasn't until the late 1990's that a renewed emphasis on conservation and planning for Yellowstone River resources began anew. This time, however, it wasn't concern about the potential paucity of water that initiated the planning effort, but rather its overabundance. One-hundred-year floods in 1996 and 1997 caused extensive erosion and sedimentation along the Yellowstone River, particularly in its upper reaches. Within the floodplain, large areas of agricultural land were eroded and existing bank protection in many areas was damaged. A significant amount of riparian habitat, crucial for many river-dependent species was eroded and washed downstream. As a result, significant public interest emerged, due in primarily to the widespread damage and the resulting bank stabilization and flood protection projects.

The controversy surrounding these projects precipitated the formation of two citizen-based Yellowstone River resource management groups: the Upper Yellowstone River Task Force (Task Force) and the Yellowstone River Conservation District Council (YRCDC). Operating from 1997 until 2003, the governor-appointed Task Force consisted of citizens representing a broad array of Yellowstone River interests from Park County. The Task Force, using a combination of state and federal funds, undertook a wide-ranging effort to collect and disseminate scientific information about the upper Yellowstone River in Park County. They produced a set of consensus-based recommendations on a wide variety of issues specific to the Yellowstone River in Park County. It was upon this work that a special federal regulatory designation called a Special Area Management Plan (SAMP) was instituted by the U.S. Army Corps of Engineers to review and authorize projects seeking to alter the bed and/or banks of a critical segment of the Yellowstone River in Park County under the Federal Clean Water Act §404 program.

In 1999, the YRCDC formed, in part to demonstrate local resource management primacy in the face of increasing national attention. The YRCDC is a coalition of conservation districts that comprise the Yellowstone River in Montana and North Dakota. Its purpose is to provide local leadership, assistance, and guidance for the wise use and conservation of the Yellowstone River corridor's natural resources to sustain and improve social, environmental, and economic values. As a result, Congress authorized the Yellowstone River Corridor Comprehensive Study, also known as the Cumulative Effects Study (CES) under Section 431 of the Water Resources Development Act of 1999 (WRDA, 1999). WRDA 1999 provides for a comprehensive study of the Yellowstone River from Gardiner, Montana, to its confluence with the Missouri River to determine the hydrologic, biological, and socioeconomic cumulative impacts on the river. In 2004, Custer County Conservation District, fiscal agent for the Council, entered into a cost sharing agreement with the U.S. Army Corps of Engineers (USACE) for this study. The study is scheduled for completion in 2015.

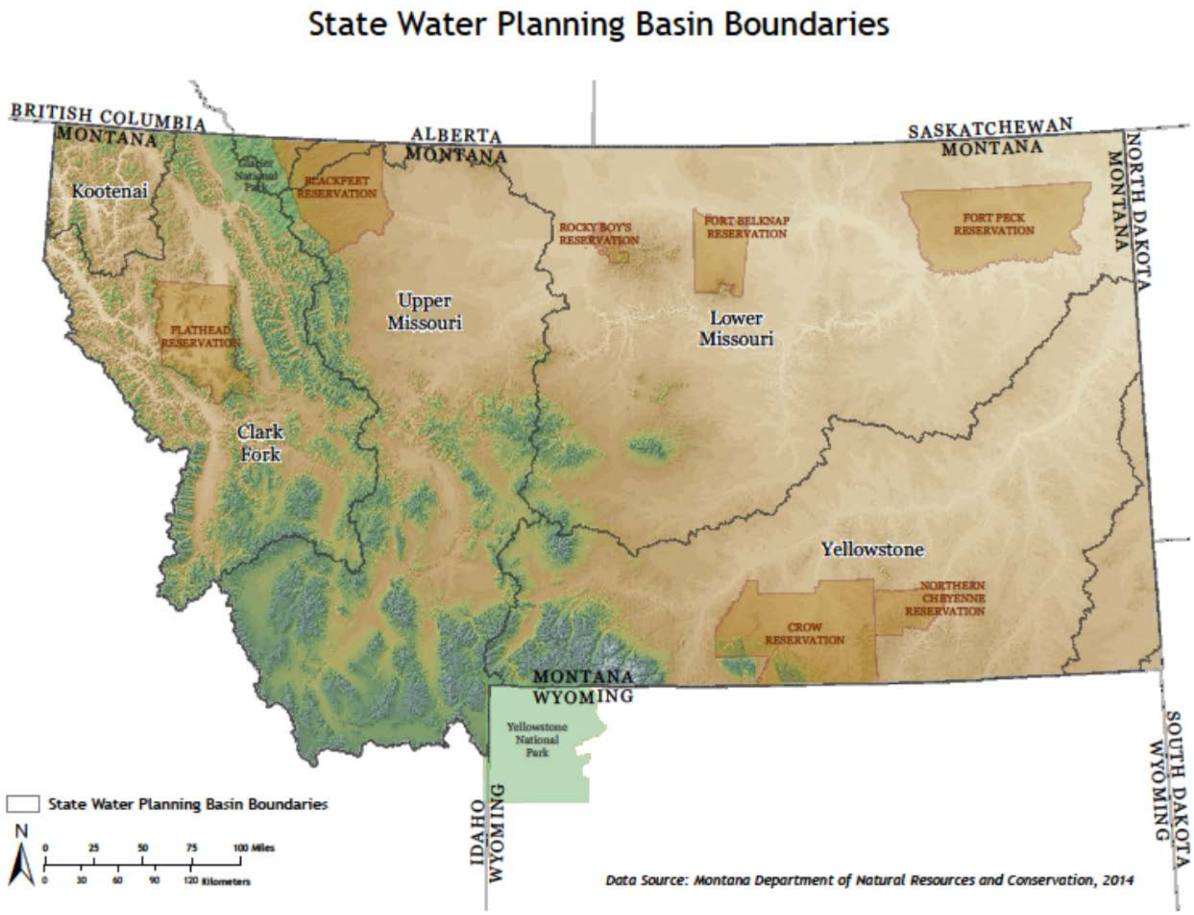
MONTANA WATER SUPPLY INITIATIVE 2015

And so Yellowstone water planning continues. Prized for the cultural heritage it embodies and the natural resources it provides, the Yellowstone basin and the water it generates is and will continue to be the subject of planning efforts intended to ensure its sustainability for present and future uses. To this day, even though the Yellowstone River is no longer used for commercial transportation and Montana's adjudication process has strengthened its claim over water originating within its borders, control over Yellowstone water for uses both within and downstream of the basin is still very much an issue for many basin water users. Although the Yellowstone contributes over half the combined average annual flow at its confluence with the Missouri, the basin comprises one of the most sparsely populated areas of the United States. Montana and Wyoming rank 44 and 50 amongst the states in population. Water users in the Yellowstone are acutely aware that despite the basin's disproportionate hydrologic and ecologic importance, a significant political disparity exists between upstream and downstream uses. As the need for control and protection of Yellowstone water has increased, so has the need to achieve the primary, yet elusive goal of water planning: ensuring and expanding water availability for present and future uses.

Yellowstone Basin Planning Methodology

The 2015 Montana Water Supply Initiative (MWSI) is a public water planning process that promotes awareness and understanding of the dynamic nature of Montana's water supply and engages citizens in planning for our future water needs. For the Yellowstone River Basin (see Figure II-1), the MWSI occurred in three primary phases that occurred over an 18-month period: *Phase 1* (Issue Identification); *Phase 2* (Information Transfer); and *Phase 3* (Recommendation Development). Phase 1 included a messaging campaign that promoted public awareness of water issues and the planning process for the Yellowstone River Basin. Phase 1 also included establishment of the Yellowstone Basin Advisory Council (Yellowstone BAC). Phase 2 included a series of presentations during the fall of 2013 from subject matter experts on issues raised during Phase 1, while Phase 3 focused on the BAC's development of recommendations to address priority issues.

Figure II-1 Major Water Planning Basins in Montana.



PHASE 1 - ESTABLISHING THE BAC, PUBLIC SCOPING PROCESS, AND ISSUE IDENTIFICATION

In January 2013, a contract was established with Montana State University-Billings to provide assistance with formation and coordination of the Yellowstone BAC activities for Phase 1 (Issue Identification). To establish the Yellowstone BAC, citizen involvement was solicited from a variety of water interests including agriculture, conservation, industry, municipal, recreation, and tribal. In the Yellowstone River Basin there are 15 conservation districts and 9 watershed groups. Each of these organizations was asked to supply a single nominee who is knowledgeable about water resource issues and interests within their district or watershed. Other key water interest organizations within the Yellowstone River Basin in Montana were asked to submit nominees. From this pool of potential members, DNRC selected a 20-member Yellowstone BAC (see Figure II-2) that, to the extent possible, is geographically distributed and representative of water interests throughout the basin.

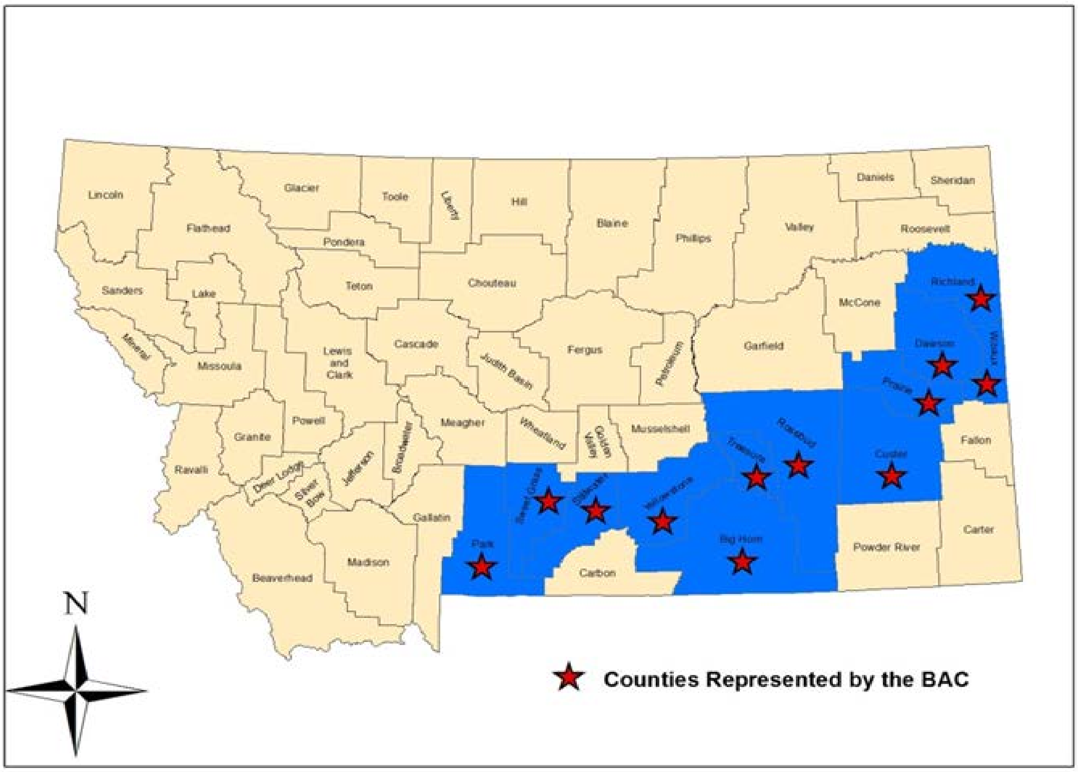
Figure II–2 Photo of Yellowstone BAC on May 8, 2013.

Back Row--Left to Right: Dan Rostad, Dave Mumford, Greg Lackman, Steve Pust, Cal Cumin, Bobbi Blankenship, Paul Gatzemaier, Jerry O'Hair, Nick Golder.

Front Row-Left to Right: Dan Lowe , Roger Muggli, Shanny Spang Gion, Mack Cole, Mike Penfold, John Pulasky, Dave Galt. (Photo by MSUB Team)

The Yellowstone BAC includes people with a broad array of water interests, ranging from irrigation, to petroleum production, to instream flows. The BAC also provides broad geographic representation. Figure II-3) illustrates the counties with representation on the Yellowstone BAC.

Figure II-3 Yellowstone BAC Representation Map.



(Blue county with red star indicates BAC representation served by at least one person) Map by: Matthew Anderson, MSU, Billings

At the request of the DNRC, eight individuals were named as ex-officio members of the Yellowstone BAC (Table II-1). These individuals attended the meetings and provided input; however, per the YBAC guidelines (Appendix A) they were not voting members.

Table II-1 Yellowstone Basin Advisory Council Ex-officio Members Spring 2013

Last Name	First	Agency
Brummond	Andy	Montana Department of Fish Wildlife and Parks (Lewistown)
Duberstein	Lenny	US Bureau of Reclamation
Frankforter	Jill	US Geological Survey
Frazer	Ken	Montana Department of Fish Wildlife and Parks (Billings)
LaFave	John	Montana Bureau of Mines and Geology
Ockey	Mark	Montana Department of Environmental Quality
Opitz	Scott	Montana Department of Fish Wildlife and Parks (Livingston)
Philbin	Mike	US Bureau of Land Management

Scoping Process/Issue Identification. In general, the scoping meetings were designed to take two hours. At the regional locations, two sessions were scheduled: a morning session (10-noon) and an afternoon session (1-3). The sessions included:

- 20-minute Overview of Planning Process
- 20-minute Overview of Hydrologic Issues
- 20-minute Overview of Water Rights
- 45-minute Roundtable Discussion
- 20-minute Q Sort Survey

The Kick-off meeting on March 18 (see Table II-2) was designed to serve two primary functions: 1) as a convening event where the Yellowstone BAC members could meet for the first time and where they could select a Chair and Vice-Chair; and, 2) as a "preview" of how the regional scoping meetings would be run.

Table II-2 Schedule of Yellowstone BAC Scoping Meetings

March-May 2013

Date	Location	Venue
March 18*	Billings	MSU-Billings Downtown Campus
March 27	Glendive	Dawson College
April 12	Big Timber	Big Timber Public Library
April 24	Forsyth	Forsyth Public Library
May 7	Billings	MSU-Billings Downtown Campus
May 8**	Billings	MSU-Billings Downtown Campus

*Primarily an organizational meeting.

**Primarily for review of public inputs and to begin prioritization of issues.

Regional Public Scoping Meetings. To provide a variety of regional opportunities for public input, four meetings were held in four different communities along the Yellowstone River. The meetings in Glendive, Big Timber and Forsyth included morning and afternoon sessions to expand opportunities for public comment at any single location. Also, as a means of accommodating people unable to attend a daytime meeting, one evening session was conducted in Billings. The public meetings were all held in settings that were politically neutral and readily accessible (see Table II-2).

Publicity for the meetings involved four primary avenues: 1) radio, 2) newspaper, 3) direct mail, and 4) personal solicitation. Some local outlets such as conservation districts and Farm Bureau newsletters offered free announcements, while others required advertising space to be purchased (see Table II-3).

Numerous local radio stations were engaged as a primary means of announcing the meetings. Local print media were also engaged as primary modes of announcing the public meetings. A third means of encouraging attendance at the regional meetings included sending meeting notices to all of the groups and organizations that received the original invitations to provide Yellowstone BAC nominations. Finally, the MSUB team placed approximately 200 telephone calls to citizens throughout the basin informing them of nearby meetings and encouraging their participation.

Table II-3 Print Advertising of Yellowstone BAC Regional Meetings 2013

Newspaper	**Run Dates**					
Miles City Star	3/22	3/25	4/16			
Glendive Ranger Review	3/21	3/24				
Sidney Herald	3/24	3/27	4/17			
Billings Gazette	3/24	4/5	4/17	4/30	5/2	5/5
Bighorn County News			4/11	4/18		
Livingston Enterprise		4/3	4/10			
Carbon County News			4/18			
Big Timber Pioneer		4/4	4/11			
Forsyth Independent Press			4/11	4/18		
Powder River Examiner		4/11	4/18			
A Cheyenne Voice		4/12	4/19			

SCOPING RESULTS

The public scoping efforts were well received in each location. As shown in Table II-4, nearly 150 public attendees participated in the meetings.

Table II-4 Public Attendance at Yellowstone BAC Meetings March-May 2013

Meeting Time and Date	**Number Of Public Attendees**
Billings, March 18	08
Glendive, March 27	24
Big Timber, April 12	43
Forsyth, April 24	32
Billings, May 7	30
Billings, May 8	11
TOTAL	**148**

Public Comment via Roundtable Discussions. Each discussion resulted in a list of concerns and an audio-recording. These materials were reviewed in a five-step process. First, the listed concerns were transcribed into sets of notes organized by meeting and discussion table. Second, the audio recordings were carefully reviewed by a research associate and explanatory details were added to the transcribed notes. Third, the various sets of notes were reorganized into question-by-question documents. Fourth, the content was organized into thematically arranged elements. Finally, the thematically arranged elements were distilled into a set of primary concerns which were edited for continuity, clarity and primacy as concerns.

As a result, the roundtable data revealed 28 primary concerns voiced by the public. These were not discrete concerns as there is certain overlap among them. They are summarized below in alphabetical order, not by order of importance:

- **Availability:** Do we know how much water is available?
- **Beneficial Uses:** Should we rethink what constitutes a "beneficial use?"
- **Current Allocations:** To what extent are we appropriated or over-appropriated?
- **Drought Readiness:** Are we ready to address water shortages?
- **Enforcement/Protecting Senior Rights:** What can be done to better enforce our water right administrative system based on the Prior Appropriation Doctrine?
- **Exempt Wells/Groundwater Wells**: Are wells impacting surface water availability in this basin?
- **Federal Reserved Rights:** Can the BAC better address the failure of water supplies to support fish and wildlife (especially as defined by federal rights that protect the fisheries, endangered species and flow regimes)?
- **Fisheries and Wildlife:** Can we determine how much water is truly needed to support wildlife and fisheries?
- **Future Allocations/Additional Rights:** How many new users can be supported? Are "closures" of sub-basins eminent? Can we avoid over-allocating?
- **Gauges/Monitoring**: Do we really know how much water is being drawn? Do we need a comprehensive system that links all monitors in the basin to one database or system of analysis? What would it take?
- **Hydrologic Models to Explore "Full Development":** Can we find a way to think about how much water is really in the system, how much is being drawn off and what it would look like if <u>all</u> of the existing rights were fully developed? Do we know what will happen if all water right holders develop their full shares?
- **Hydrologic Models to Explore Variability:** Can we anticipate what it will mean to experience extremely variable episodes of available snowpack or rainfall?
- **Incentives and Support for New Technologies and Conservation Practices:** Should we seek governmental support to encourage water use technologies that maximize efficiencies? Should we reward conservation?
- **Industrial Uses of Water:** Do we know how much water industry is using? How do we ensure the needs of industrial users? How much water does fracking (hydraulic oil well fracturing) really use?
- **Irrigation Technologies and Growth:** Do we know the circumstances when flood irrigation is preferable to sprinkler irrigation?
- **Instream Flows:** What are the instream flow requirements? Can we devise management plans that work to serve all needs?
- **Invasive Species:** To what extent are invasive species, such as salt cedar and Russian olive, reducing our available water? Can we reduce the problem?
- **Montana as Priority:** Have we done all we can to get our share from Wyoming? Have we done all we can to keep water in Montana? To what extent are we beholden to barge traffic on the Missouri or Mississippi? Are we prepared to fully protect our water rights from parties located outside the state?
- **Municipal Uses, Urban Development and Population Growth:** To what extent might significant growth in municipal draws impact availability?

- **Planning for Water Demands:** Can the YBAC better match water supplies to demands, especially where shortages currently occur? Can the BAC look further down the road than 20 years? Can we revisit the planning process every few years instead of every few decades? How should future planning be financed?
- **Recreational Uses:** Do we know how to value recreational uses? If recreational demands increase, how will that impact other user groups? Will river access issues be addressed by this plan? Are recreational uses fully developed?
- **Stock Water Ponds and Tanks/Fishing Ponds:** How much water is retained? How much is lost to evaporation? Should these practices be addressed? Might more creeks be dammed to store water?
- **Tribal (Reserved) Rights:** To what extent are tribal rights already developed? What is the impact if tribal rights are fully developed?
- **"Use it or Lose it" Principle:** Is this the best model for encouraging water conservation? Should this be modified? Are ditch companies intentionally wasting water as insurance against "losing it?"
- **Water Market Transfers:** Should Montana stop allocating and start a new transfer system? Is water already in a "loose" market system that needs to be watched over more carefully? What are other states doing in terms of water markets?
- **Water Quality:** To what extent is quality a concern within issues of availability? Do we monitor quality in a satisfactory manner? Can we better address non-point source pollution, especially agricultural run-off? Do we understand "natural pollutants" in the Montana water system?
- **Water Reservations:** Is it possible to honor all of the Yellowstone Water Reservations and not impact existing senior users? What if they are fully developed? How can we maintain instream flow reservations?
- **Water Storage:** What are the options for storing more water? How will projects be paid for? Can smaller projects help individuals and the state? Are off-stream reservoirs a viable option?

PRELIMINARY RANKING OF ISSUES.

At the May 8th Scoping Wrap-up Meeting, the Yellowstone BAC members were provided a list of issues that had been brought forward by the public and were given approximately two weeks to make their rankings and to return them to Gilbertz who separately calculated overall rankings for the BAC voting members and for the BAC Ex-Officio members. See the final Yellowstone BAC scoping report for the methodology (http://dnrc.mt.gov/mwsi).

Table II-5 Yellowstone BAC Issue Rankings

Concern	Number with this as #1 Rank	Number who ranked this as 1-7
Availability	10	13
Drought Readiness	1	11
Enforcement/Protecting Senior Rights	1	7
Water Quality	1	7
Instream Flows	0	6
Shifting Practices: Irrigation Technologies	0	6

Concern	Number with this as #1 Rank	Number who ranked this as 1-7
Future Allocations/Additional Rights	0	5
Incentives and Support for New Technologies and Conservation	0	5
Storage Capacities	0	5
Reservations (Protected MT Rights)	0	4
Current Allocations	1	4
Planning	0	4
Beneficial Uses	1	3
Montana as Priority	1	3
Gauges/Monitoring	0	4
Municipal Needs, Urban Dev & Pop	0	3
Shifting Practices: Water to Industry	0	4
Water Market Transfers	1	3
Hydrologic Model –Variability	0	2
Hydrologic Model—Full Development	0	3
Recreational Uses	0	2
Exempt Wells/Groundwater Wells	0	2
Fisheries and Wildlife	0	1
Invasive Species	0	2
Stock Ponds and Tanks/Fishing Ponds	0	1
Use It or Lose It Principle	0	1
Hydraulic Fracturing (Fracking)	0	1
Tribal (Reserved) Rights	0	1

Table II-5 documents the calculated rankings for the Yellowstone BAC. Issues for which no ranking was offered by any member of the YBAC have been left off the list. In the third column, the list also indicates the number of respondents that ranked each issue as #1 (most important).

<u>Public Input—Written Comments</u>. MSUB faculty (Gilbertz) served as the primary contact during the scoping process. All written comments, including those gathered at meetings, via email or by postal delivery, were directed to her office. A complete record of all written comments is found in Appendix G of the Scoping Report located at http://dnrc.mt.gov/mwsi .

PHASE 2 - INFORMATION TRANSFER

The Yellowstone BAC met twice in Billings, on November 14-15 and December 13, 2013, to complete the work of Phase 2. The Information Transfer phase was designed to provide the YBAC members with the most current science and information on the topics of importance identified by the Phase 1 scoping. This was accomplished by inviting technical experts on the various issues to make presentations to the YBAC and be available for follow-up questions and discussion. The presentation topics covered during this phase were initially identified by DNRC staff based on the results of Phase 1 and then approved by the YBAC members.

The YBAC members heard presentations from state and federal experts, legal and non-profit interests, and an experienced on-the-groundwater commissioner. Taken together, the presentations provided everything from a scientific background to practical advice on what is working on the ground now, and thoughts on enhancing water management in the future. The overarching topics addressed were: water administration, reallocation tools, and drought management; climate science and water information tools; water quality and beneficial use; reservoir operations, tribal compacts, and the hydrological effects of present-day water development; instream flow programs; groundwater-surface water nexus; and, the executive and legislative process for recommendations.

The YBAC did not develop any formal input during Phase 2. There was brief discussion following the presentations and during selection of the issues to advance for recommendations. The YBAC discussed among other topics:

1. importance of information from monitoring,
2. difficulty of placing a monetary value on the water resource,
3. amount and use of water for hydraulic fracturing for petroleum extraction,
4. water quality and the relationship between water quality and quantity,
5. roles of the various agencies in water management (DNRC, DEQ, etc.),
10. tools available for instream flow protection, their uses, and some of their limitations,
11. impacts of climate change on water availability,
12. benefits of local watershed groups,
13. water information that is currently available to the public,
14. operations of Yellowtail Dam in the Bighorn watershed,
15. what to expect with the Crow Compact settlement,
16. relatively minor impact of groundwater withdrawals (for all uses) compared to surface water uses on water availability,
17. artificial aquifer situations created by human activity, and
18. need for communication on water management between Montana and Wyoming (especially in the Tongue watershed.)

PHASE 3 - RECOMMENDATION DEVELOPMENT

Several things were done to prepare for the Recommendation Development phase. The list of all scoping issues and their previous ratings by the YBAC was revisited and validated, key decisions previously made by the YBAC were revisited, and proposed screening criteria for recommendations were revisited and validated.

YBAC facilitator and coordinator, Barb Beck, proposed a process to the YBAC members for developing recommendations. The process was acceptable to the YBAC members and recommendations were developed in Phase 3 using the following steps:

1. Define the issue under consideration,
2. Describe the ideal situation with respect to that issue (desired future condition),
3. Ask the following questions,
4. What did we learn about this issue during scoping in Phase 1?
5. What did we learn about this issue from the experts in Phase 2?
6. Who is affected and how?
7. Do we need to make a recommendation on this issue? If yes,
8. What do we want to recommend?
9. How does this recommendation meet the criteria we have agreed upon? And, do we understand the consequences of this recommendation?

DNRC staff developed a summary of the scoping issues across all of the major basins to update the Environmental Quality Council standing legislative committee and the Water Interim Policy Committee in January 2014. Prior to the legislative committee presentation, the Yellowstone BAC Chair, Mack Cole and Vice Chair, John Moorhouse reviewed and commented on the draft summary of scoping issues document for the Yellowstone Basin. The eight priority issues for the Yellowstone Basin provided the foundation for recommendation development in Phase 3:

1. Drought readiness,
2. Water information,
3. Integrated water quality and quantity management,
4. Water administration and beneficial use,
5. Watershed planning,
6. Groundwater/surface water nexus,
7. Instream flow maintenance, and
8. Water storage.

The YBAC held three recommendation development meetings on February 25, March 12, and April 9 of 2014. During discussions, the YBAC recognized that they were operating within the prior appropriation legal framework. The fourth and fifth YBAC recommendation development meetings took place on April 25 and May 29. During the April 25 meeting, the YBAC reviewed the entire package of preliminary recommendations and prepared for the four public comment meetings held May 12, 13, 14, and 15 in Glendive, Forsyth, Billings and Big Timber, respectively. At their May 29 meeting, the YBAC reviewed the public comments and finalized their recommendations.

Several overarching themes surfaced as the YBAC developed and discussed the preliminary recommendations:

1. The recommendations should not threaten the prior appropriation doctrine.
2. The recommendations should be stated in simple, non-technical terms.

3. There should not be redundancy of recommendations where issues overlap, for emphasis, or for any other reason.
4. YBAC wanted to and did consider water issues within their charge regardless of which state agency has the lead for a particular issue. For example, water quality was important to the YBAC although the lead for this issue is the Montana DEQ rather than the DNRC.
5. The YBAC believes that state agencies should work closely together to benefit water users and Montanans.
6. The YBAC was conscious of the financial implications of recommending anything new or adding a level of effort to on-going work.

Phase 2 and 3 YBAC Coordinator Barb Beck prepared a draft of the Recommendation Development Report (RDR), once the YBAC had completed its work on the preliminary recommendations. The draft RDR was approved by the YBAC on April 25, 2014, for release to the public and was posted on the Yellowstone BAC web page (http://dnrc.mt.gov/mwsi) for the duration of the public comment period which ran from May 2 to May 23.

Following the close of the public comment period, the summary of public comments was provided to the YBAC via e-mail. This summary is available on the Montana Water Supply Initiative web page (http://dnrc.mt.gov/mwsi).

The YBAC held their final meeting on May 29, 2014 to consider public comments. The comments were discussed at the meeting, oral public comments were heard, and the preliminary recommendations were finalized.

Two recommendations did not have full consensus of the YBAC. One recommendation each under Water Administration and Beneficial Use, and Instream Flow Maintenance did not have consensus. The text of the two recommendations is as follows:

Water Administration and Beneficial Use Issue

PRELIMINARY RECOMMENDATION D.3.B

"Require all users to measure at or near the point of diversion from the river or stream."

Instream Flow Maintenance Issue

PRELIMINARY RECOMMENDATION I: CHANNEL MAINTENANCE

"Recognizing lateral migration processes as important, efforts to maintain instream flows should include provisions for retaining or reestablishing alluvial channel form and function with associated biological communities."

Those present at the May 29 meeting voted on the two recommendations and they were affirmed by the majority present. The coordinator was asked to poll those YBAC members not present so that the vote could include all YBAC members, not only those present at the meeting.

The coordinator polled the absent members via e-mail. Both recommendations were affirmed by the majority of the YBAC at the meeting and again once the polling was completed. A minority report was drafted by the coordinator and reviewed and approved by the minority voters in each case. The minority reports are presented in Appendix D of the Recommendation Development Report (See http://dnrc.mt.gov/mwsi).

At the meeting on May 29, the YBAC worked systematically through the summary of public comments by issue and recommendation to finalize the language in the recommendations. They noted and specifically discussed comments provided by the public that were in opposition to their recommendations, new topics that they had not considered, and a variety of other suggestions from the public

To address recurring public concerns about perceived threats to the prior appropriations doctrine the YBAC directed staff to add language to both the Executive Summary and the Introduction of the Recommendation Development Report. Language was added explaining that the YBAC's work was conducted within the framework of the prior appropriations doctrine.

The YBAC did not make any changes to the preliminary issue statements but did make a small number of wording changes to goal statements and recommendations in response to public comments--to better clarify their intent. The meeting notes from May 29 document the changes that were made between the preliminary and final recommendations. The YBAC did not delete any recommendations. One recommendation was added. Recommendation B.2 was added under the Groundwater/Surface Water Nexus Issue to encourage action by the Legislature to optimize the use of surface and groundwater resources.

The final recommendations as approved by the YBAC are provided in Section IX of this report.

Water Resource Project and Program Funding

Most water resource improvement projects in Montana are a collaboration that starts at the local level. Funding is often leveraged from a variety of sources to support a single project. Montana offers numerous grant programs aimed at conserving, protecting, and expanding the beneficial use of Montana's water.

Grant Programs available through the Department of Natural Resources and Conservation include:

1. **Renewable Resource Project Grants** fund projects that conserve, develop, preserve or improve management of Montana's renewable resources such as water. Grants are available up to $125,000.
2. **Renewable Resource Planning Grants** support planning activities for projects that are eligible for Renewable Resource project grants (above). Grants are available up to $10,000.
3. **Capacity Grants** provide funds for conservation districts and watershed groups to build their capabilities, knowledge, and resources in order to fulfill their mission. Grants are available up $20,000.
4. **Reclamation and Development Project Grants** fund activities that reclaim natural resources damaged by mineral extraction, hazardous waste or activities that meet a crucial state need. Grant limit is $500,000.
5. **Reclamation and Development Planning Grants** provide up to $50,000 to support planning for a natural resource projects eligible for Reclamation and Development Project Grants (above).
6. **Reclamation and Development Aquatic Invasive Species Grants** fund projects that protect natural resources from aquatic invasive species. Grants are available up to $25,000.
7. **Irrigation Development Grants** fund projects leading to development of new irrigation or increased value of agriculture. Grants are available up to $20,000.
8. **Private Water Grants** are available to individuals or non-governmental groups for up to $5,000 or 25% of project costs whichever is less. These grants fund projects that benefit water resources.
9. **Emergency Grants** fund activities needing immediate attention to prevent substantial damage or legal liability. Must benefit or develop renewable resources such as water.

10. **Conservation District Grants** (House Bill 223 Grants) provide up to $20,000 to fund conservation district soil and water conservation natural resource related projects. Eligible projects must be sponsored by a Montana Conservation District.
11. **Conservation District Development Grants** are intended to increase a conservation district's ability to meet statutory requirements of developing and implementing locally led conservation projects. Grants are available up to $10,000.
12. **Education Mini-Grants** provide up to $500 in funding for educational programs that address natural resource conservation. Eligible projects must be approved by a Montana Conservation District.

Grant Programs available through the Department of Fish Wildlife and Parks include:

1. **Future Fisheries Improvement Program** has provided an average of approximately $800,000 annually since its inception in 1995 to restore essential habitats for the growth and propagation of wild fish populations in Montana's lakes, rivers and streams. Contact the Montana Dept. of Fish Wildlife and Parks for additional information http://fwp.mt.gov .

Grant Programs available through the Department of Environmental Quality include:

1. **The Montana Department of Environmental Quality's (DEQ) 319 Grant Program** provides funds to restore water quality in water bodies whose beneficial uses are impaired by nonpoint source (NPS) pollution and whose water quality does not meet state standards. DEQ strongly encourages the development and implementation of science-based, locally-supported Watershed Restoration Plans (WRPs) to guide these efforts.

III. Yellowstone River Basin Profile

Current Population

As of July 1, 2013 the population of the Yellowstone River Basin in Montana stood at 254,858 or about 7 people per square mile. Figure III-1 shows the geographic population distribution as of the 2010 census. Populations of individual counties within the Basin for 2013 are listed in Table III-1. More than 60 percent of the Basin's residents live in Yellowstone County. Figure III-2 compares the 2013 population of Montana's portion of the Yellowstone basin with the Billings Metropolitan Area.

Figure III-1 2010 Population Distribution of the Yellowstone River Basin in Montana.

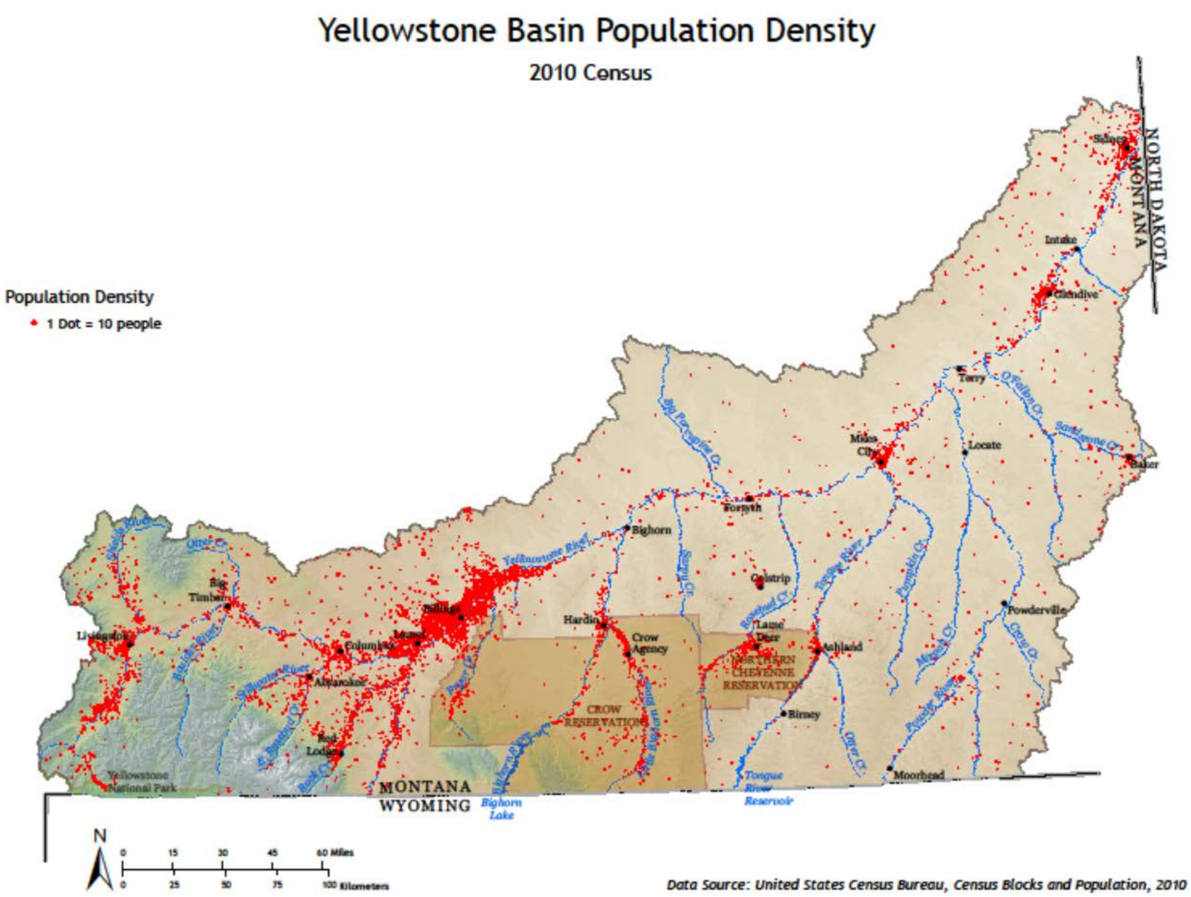
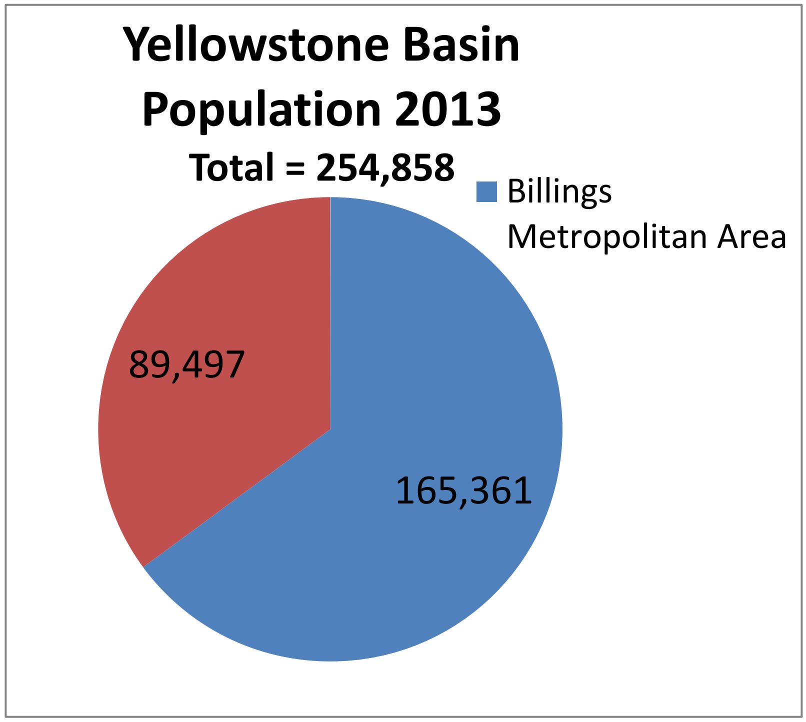


Table III-1 Populations of Montana Counties in the Yellowstone Basin for 2013

County	Pop.
Big Horn	13,042
Carbon	10,340
Custer	11,951
Dawson	9,445
Fallon	3,079
Park	15,682
Powder River	1,748
Prairie	1,179
Richland	11,214
Rosebud	9,329
Stillwater	9,318
Sweet Grass	3,669
Treasure	700
Yellowstone	154,162
TOTAL	254,858

Figure III-2 Population Distribution of the Yellowstone River Basin in Montana.



Source: U.S. Census Bureau, Population Division

Population Trends

RECENT POPULATION TRENDS

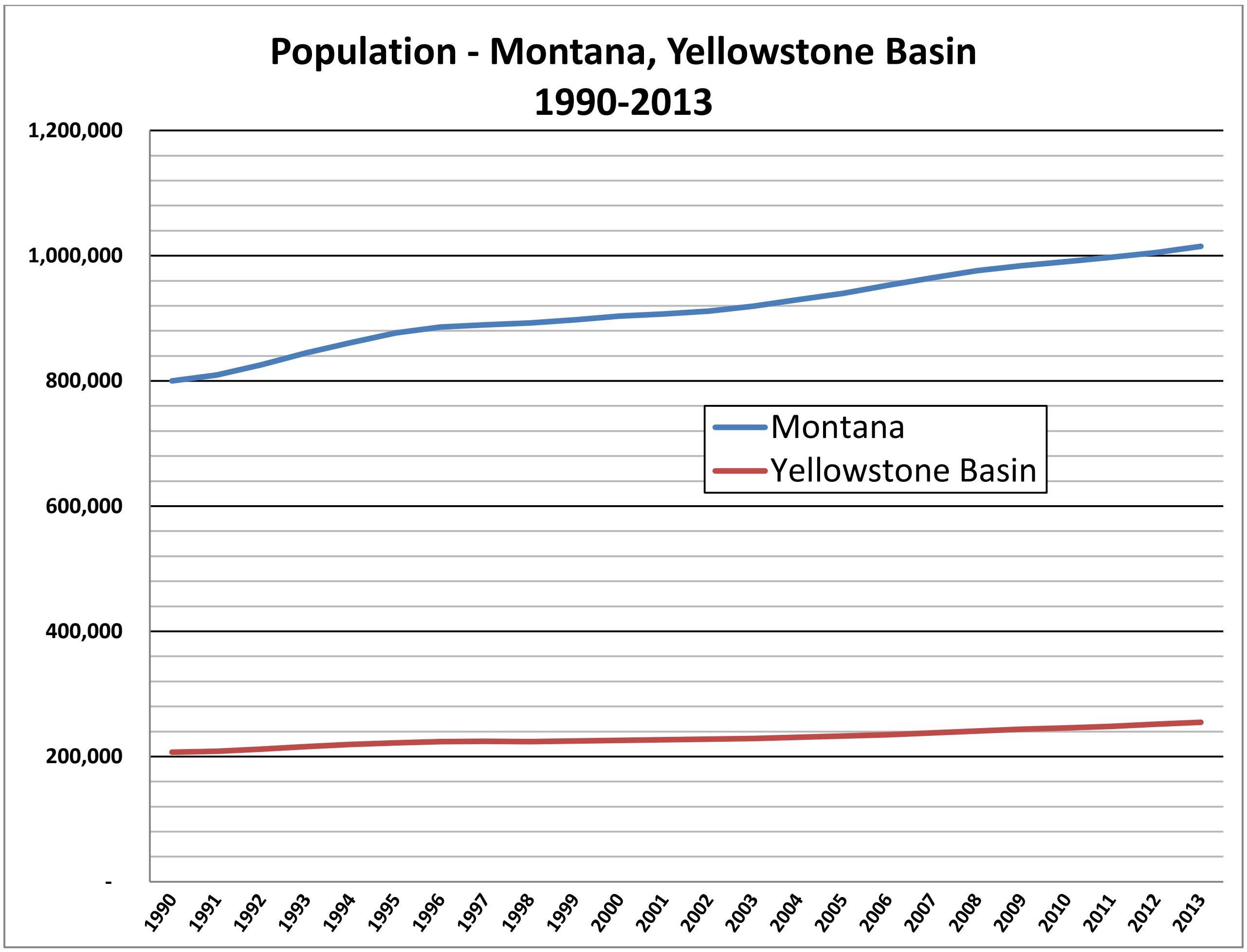
Between the 2010 census and July 1, 2013, the population of the Yellowstone Basin increased 3.8 percent to 254,858. During the same period Montana's population increased 2.6 percent to 1,015,165. Populations for the Billings Metropolitan Area and for the rest of the Yellowstone Basin grew by 4 percent and 3 percent, respectively, between 2010 and 2013. Growth for these parts of the Basin exceeded Montana's growth rate for the period of 2.6 percent.

Among U.S. counties with populations exceeding 10,000, Richland County ranked 19th in population growth between 2012 and 2013, growing by 3.7 percent to 11,214. Richland County's population increased by 15.1 percent between 2010 and 2013. Carbon County ranked 92nd for population growth between 2012 and 2013, increasing by 2.2 percent to 10,340.

HISTORICAL POPULATION TRENDS

Between 1990 and 2013, the population of the Yellowstone Basin increased by 23 percent while Montana's population increased by 27 percent (Figure III-3). Stillwater, Yellowstone, and Carbon Counties were the most rapidly growing counties with populations increasing by 42 percent, 36 percent, and 28 percent, respectively. The populations of four counties in the Basin declined over the period.

Figure III-3 Population Growth Trends for the State of Montana and the Yellowstone Basin in Montana.



INDIAN RESERVATIONS

The populations of Indian reservations in the Basin totaled 11,652 in 2010 with nearly 60 percent residing on the Crow Indian Reservation. Table III-2 displays the populations of the Crow and

Table III-2 Population Change of Crow and Northern Cheyenne

Reservations	Population 2010	% Change (2000-10)
Crow	6,863	-0.5
Northern Cheyenne	4,789	7.1
Total	11,652	2.5

Northern Cheyenne Reservations and Off-Reservation Trust Land and the percentage change in population between 2000 and 2010. The population for the Northern Cheyenne Reservation increased by 7 percent while the population of the Crow Reservation declined slightly during the decade.

The changes in population for Yellowstone Basin counties for the periods 1990 to 2010 and 2000 to 2010 are displayed in Table III-3. Stillwater and Yellowstone Counties grew most rapidly between 1990 and 2010 with populations increasing by more than 30 percent. The populations of Treasure, Powder River, Prairie, and Rosebud Counties declined during the period by more than 10 percent. The populations of Stillwater and Yellowstone Counties increased by more than 10 percent between 2000 and 2010. Five counties experienced population declines during the decade. Montana's population increased by 24 percent between 1990 and 2010 and by 10 percent between 2000 and 2010.

Table III-3 Population Change – Yellowstone Basin Counties

	Percent of Change	
County	**1990-2010**	**2000-2010**
Big Horn	14.2	2.0
Carbon	24.6	5.3
Custer	0.1	0.2
Dawson	-5.1	-1.3
Fallon	-6.0	2.5
Park	6.4	-0.8
Powder River	-16.7	-6.3
Prairie	-13.2	0.7
Richland	-8.4	1.3
Rosebud	-11.6	-1.5
Stillwater	38.5	10.4
Sweet Grass	15.1	-0.3
Treasure	-17.1	-15.8
Yellowstone	30.7	14.6

POPULATION PROJECTIONS

Two sets of population projections are offered here. One set extrapolates trends seen in the period between the 1990 U.S. Census and the 2010 U.S. Census. These projections are provided at the state, county, basin, and sub-basin levels (for sub-basin projections see Table VII-2). The other set relies on projections at the state and county levels developed by the Montana Department of Commerce (MT Commerce) using eREMI, a population projection product of Regional Economic Models, Inc. (REMI). Population levels were projected through the twenty-year planning period to 2035.

Table III-4 displays projections of the Yellowstone Basin's population based on each method. The MT Commerce forecasts predict a population increase for the Yellowstone Basin by 2035 that is about three-fourths of the projection that relies on extrapolations of U.S. Census trends from 1990 to 2010. Extrapolating Basin-wide population growth at the average annual rate of population change for the period between 1990 and 2010 would result in 59,364 additional residents in 2035 and an estimated population of 304,426, or one-quarter of the state's projected population. Over 90 percent of the increase would occur in the vicinity of Billings. These projections do not include the notable recent population changes in the lower Yellowstone since 2010.

Table III-4 Yellowstone Basin Population Projection 2035

	Average Annual Rate	2035	Change 2010-2035
1990-2010 Census Extrapolation	0.87%	304,426	+ 59,364
MT Commerce	0.62%	287,201	+ 41,223

Table III-5 Population Projections for Yellowstone Basin Counties

	1990-2010 Census Extrapolation	MT Commerce
Big Horn	15,145	11,135
Carbon	13,061	9,307
Custer	11,908	15,395
Dawson	8,760	9,816
Fallon	2,822	4,273
Park	16,777	15,883
Powder River	1,443	1,859
Prairie	974	1,457
Richland	9,764	13,389
Rosebud	8,116	9,016
Stillwater	13,384	8,341
Sweet Grass	4,273	4,280
Treasure	593	859
Yellowstone	206,018	182,191
TOTAL	313,036	287,201

Table III-5 shows estimated populations for the Basin's counties in 2035 as projected by each method. Generally, the MT Commerce forecasts predict more moderate rates of population change for counties compared to the trends of recent decades. That is, rapidly growing counties are predicted to grow less rapidly, counties with very slow rates of growth are expected to see increasing rates of growth, and counties with declining populations are predicted to shrink at decreasing rates. The sum of the county projections does not equal the basin population projected due to compounding effects related to the basin and county projection calculations.

Land Use and Ownership

The Yellowstone River basin drains nearly 70,000 square miles, including Yellowstone National Park, vast areas of grass and shrubland in the Northwestern Great Plains and the Wyoming Basin, forested areas in the Rocky Mountains and many small population centers, the largest of which is Billings. The Basin's area is almost evenly split between Montana and Wyoming with approximately 51 percent of the Basin's land area within Montana, 48 percent within Wyoming, and the remaining 1 percent within North Dakota. Figure III-4 shows land cover types in Montana's portion of the basin developed from the National Land Cover Database. The agricultural classification registers at just over 2 million acres. This total includes both dryland as well as irrigated agriculture. For more information about irrigated acreage estimates see Chapter V – Water Use in the Yellowstone Basin.

Figure III-4 Yellowstone Basin Land Cover Map.

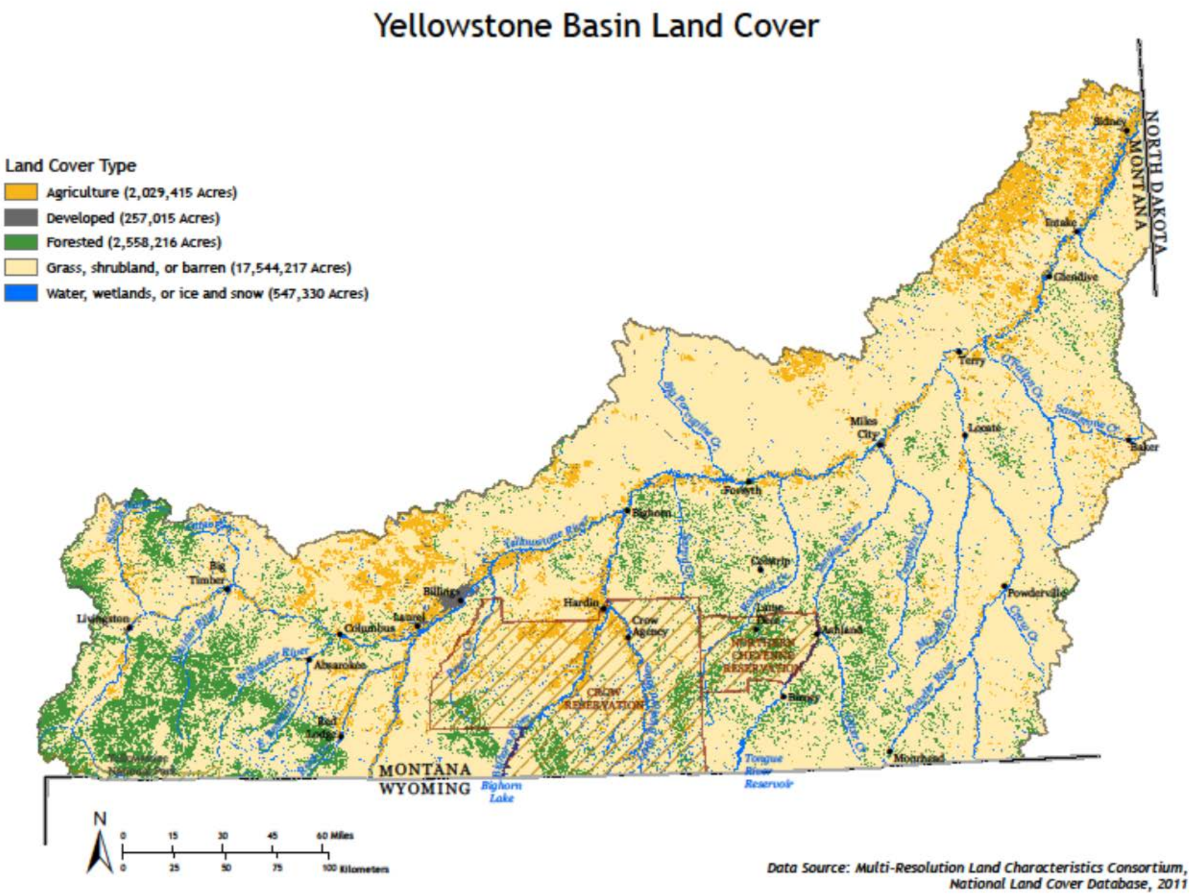
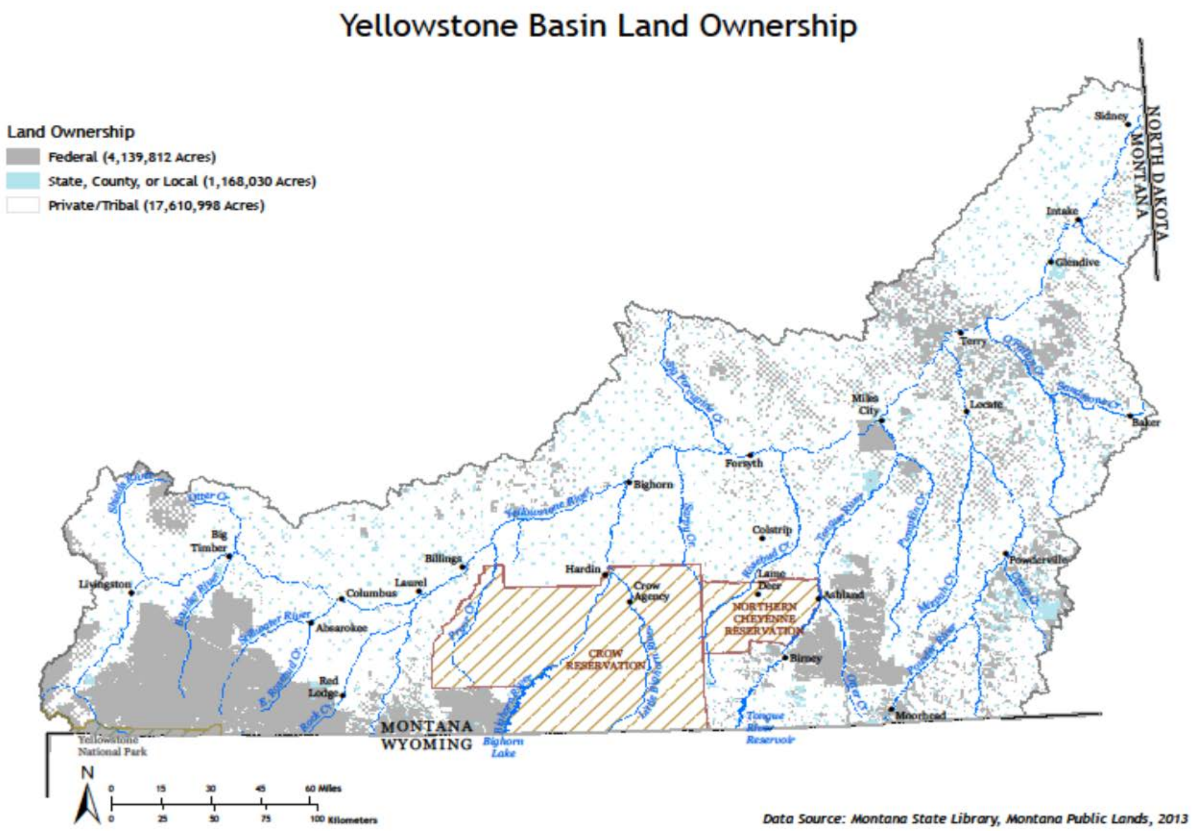


Figure III-5 shows the distribution of general land ownership categories with Montana's portion of the Basin. Approximately 77 percent, is either privately held or within one of the two tribal reservations - Crow or Northern Cheyenne. Federal lands, administered by either the Forest Service, Bureau of Land Management, or National Park Service account for another 18 percent, while another 5 percent of the land belongs to the State of Montana or local jurisdictions such as cities and counties.

Figure III-5 Yellowstone Basin Land Ownership Map.



Key Economic and Water Use Sectors

AGRICULTURE

There are an estimated 2.5 million acres of irrigated land in Montana, with approximately 600,000 acres in Montana's portion of the Yellowstone Basin (see Chapter V – Water Use in the Yellowstone Basin). More than half the diverted water is used for hay production. The next highest use is pasture irrigation, then barley production, then sugar beets.

Crop types affect the timing of water demands and the potential for water shortages. For grain, irrigation demand may be high in the early- to mid- summer period and much lower during the 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 the Yellowstone 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 due to increased production. Flood irrigation typically diverts more, but much of the water returns to streams through groundwater or surface return flows. Most water used for agriculture in the Yellowstone is supplied through unlined open ditches.

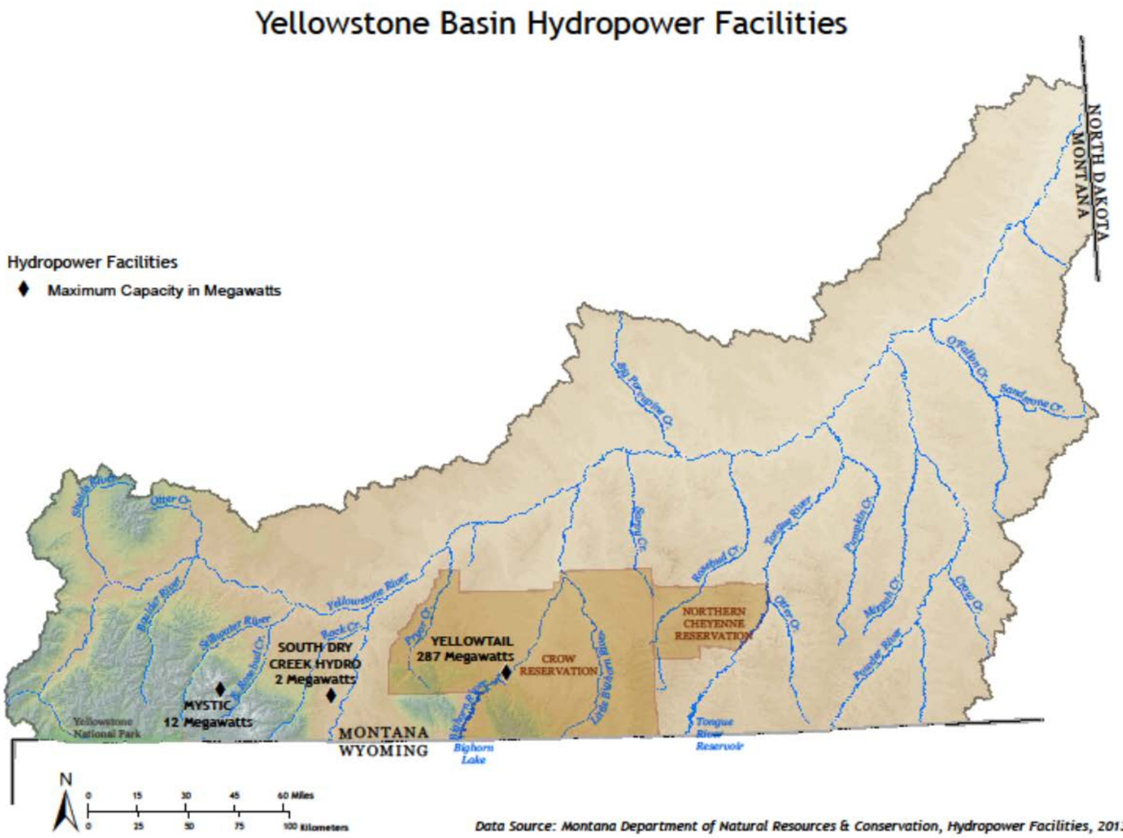
INDUSTRIAL, MINERAL AND ENERGY RESOURCES

Industrial water uses in the basin include mining, petroleum production and refining, hydropower generation, coal-fired power generation and non-agricultural food production. Coal, oil, metals, and natural gas are natural resources mined in the Yellowstone River watershed. Coal is found underground near Forsyth, Montana, and also in those parts of the basin within Wyoming. Several large active coal mines exist at Decker near the Tongue River reservoir, and two metal mines - the Stillwater Mine near Nye, and the East Boulder Mine near Big Timber produce platinum and palladium. Oil and natural gas production occurs in the east and southeast parts of the basin within the state where some consumptive use occurs for the hydro fracturing process. Two petroleum refineries exist in the basin near Billings: Exxon-Mobil and Conoco-Phillips, as does a sugar beet refining facility. All of these uses are relatively small in comparison to water used for irrigated agriculture.

Water rights are required for all beneficial uses of water, including industrial uses. Coal-fired electricity is generated from the Colstrip plants located in Rosebud County. The Colstrip plants produce up to 2,094 megawatts (one megawatt can satisfy the average energy needs of 750 households) of electricity from coal using steam created by the burning of the coal. The water for the steam is pumped 30 miles from the Yellowstone River. The Colstrip facility is the second largest coal-fired project west of the Mississippi. It uses one rail car's worth of coal every five minutes and has a surface water right for approximately 50,000 acre-feet per year

The Yellowstone's largest hydropower generating facility is associated with Yellowtail Dam on the Bighorn River. Bighorn Lake is the reservoir formed behind the dam, and has a capacity of 1,381,189 acre-feet. The dam's hydroelectric plant has a capacity of 250 megawatts. The other significant hydropower facility in Montana's portion of the Yellowstone basin is located at Mystic Lake Dam on West Rosebud Creek in the Beartooth Mountains. The hydropower facility consists of two generating units that have a total generating capacity of 12 megawatts. Figure III-6 shows hydropower generating facilities in the Yellowstone River Basin.

Figure III-6 Yellowstone Basin Hydropower Facilities.



MUNICIPAL AND DOMESTIC

This water use category includes individual on-site wells, major municipality water supply systems, and community systems in subdivisions. There are 195 municipal water rights recorded in the Basin, and about 21,144 individual domestic well permits (purposes include domestic, lawn and garden, and fire protection). Municipal suppliers have diverse demands they must fulfill, which makes planning challenging. Water quality comes into play as well. Municipal water demand figures vary widely, and may include residential, commercial, industrial, universities and government agencies. In general, in-home water use is not highly consumptive, but lawn and garden uses are. Within the Yellowstone basin, seven cities and the town of Broadus have water reservations for future use (see Chapter VI, Yellowstone Water Reservations).

RECREATION AND TOURISM

Recreation and tourism are major uses of water in the Yellowstone Basin. Of the 54 state parks in Montana, 8 are located in the basin, three being water-based parks. Other major water-related recreational attractions include the 47 fishing access sites along the main stem of the Yellowstone River, the area's many trout streams, the tail water fishery below the Yellowtail Dam, Cooney and Tongue River reservoirs, and the extensive public lands including Yellowstone National Park. Fishing and boating remain popular recreational activities in the Yellowstone basin and Montana residents often make use of its rivers, streams, natural lakes and reservoirs.

Out-of-state visitors often comment that clean waterways are among the most important attributes to their experience. Both DEQ and FWP have instream water reservations intended to maintain water quality and habitat (See Yellowstone Water Reservations in Chapter VI – Water Administration).

Environmental Concerns

The Yellowstone River is the longest unimpounded river in the conterminous United States, and as such is a rare model of the structure and function of a large western river ecosystem. However, as demonstrated by the Yellowstone River Cumulative Effects Study sponsored by the Yellowstone Conservation District Council and the U.S. Army Corps of Engineers (see http://nris.mt.gov/yellowstone), a variety of anthropogenic factors influence the river's fauna. The Yellowstone River's natural snow-melt driven hydrograph has been altered, it's longitudinal, lateral, and main stem to tributary connectivity has been reduced, a variety of structures such as bank revetments (i.e., riprap), flow deflection structures (barbs, jetties, spur dikes, etc.) and flow confinement structures (i.e., levees, berms, dikes, etc.) have been installed along the banks and in the floodplain, and several nonnative fish are present. In addition, the riparian zone has been invaded by a number of invasive plant species such as Russian Olive and Salt Cedar that can have significant adverse effects on terrestrial habitat near water bodies.

Table III-6 lists fish species of concern in the Yellowstone River as indicated by the Montana Natural Heritage Program.

Table III-6 Fish Species of Concern in the Yellowstone River

Common Name	Scientific Name	Status
Pallid Sturgeon	Scaphirhynchus albus	G2, S1, E
Blue Sucker	Cycleptus elongatus	G3/G4, S2/S3
Paddle Fish	Polyodon spathula	G4, S2
Sturgeon Chub	Macrohybopsis gelida	G3, S2/S3
Yellowstone Cutthroat	Oncorhynchus clarki bouvieri	G4/T2, S2

HERITAGE PROGRAM RANKS (STATUS)

The International Network of Natural Heritage Programs employs a standardized ranking system to denote global (range-wide) and state status. Species are assigned numeric ranks ranging from 1 (highest risk, greatest concern) to 5 (demonstrably secure, least concern), reflecting the relative degree of risk to the species' viability, based upon available information. Global ranks are assigned by scientists at NatureServe (the international affiliate organization) in consultation with biologists in state natural heritage programs and other taxonomic experts.

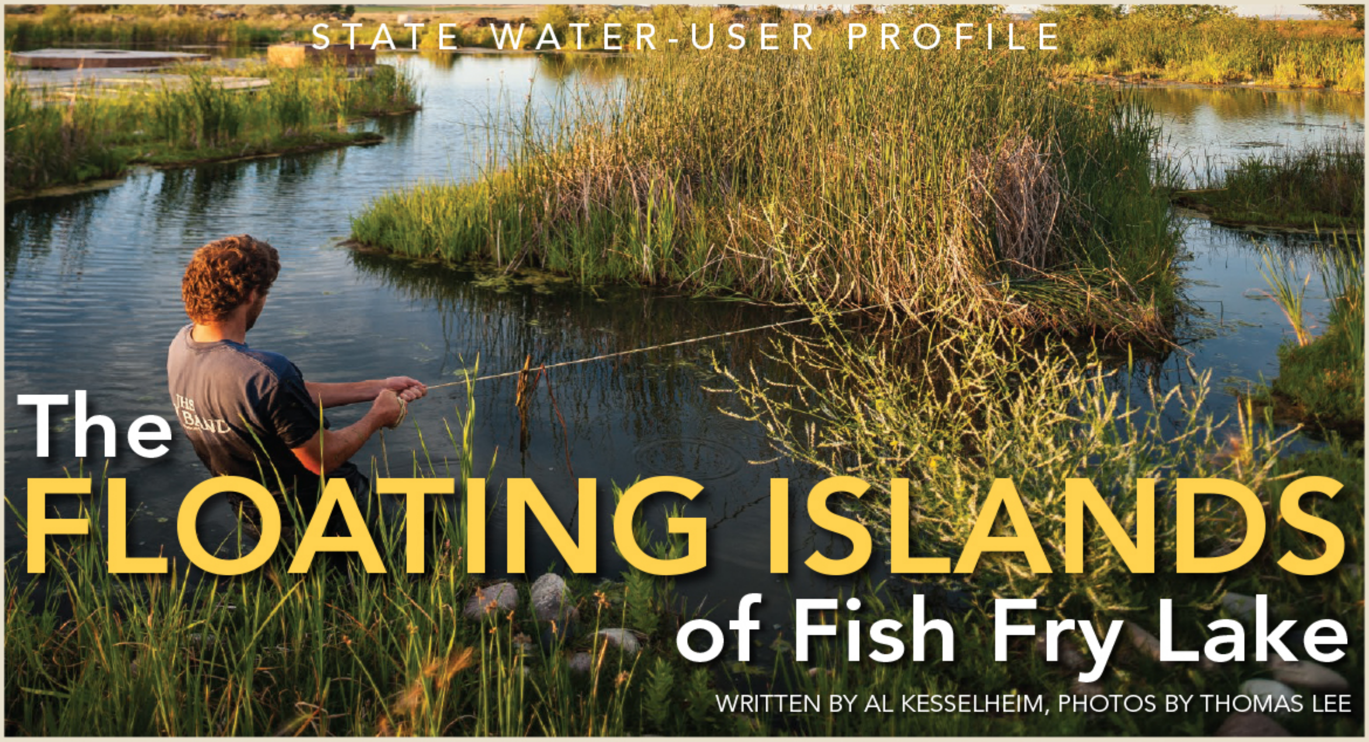
The combination of global (G) and state (S) ranks helps to describe the proportion of a species' range and/or total population occurring in Montana. For instance, a rank of G3S3 indicates that Montana comprises most or a very significant portion of an animal's total population. In contrast, an animal ranked G5S1 often occurs in Montana at the periphery of its much larger range; thus, the state supports a relatively small portion of its total population. Combination ranks indicate that a range of uncertainty exists about the status of a species (G#G# or

S#S#). A T# designation indicates the rank of a subspecies or variety and is appended to the global rank of the full species (e.g., G4T3). An E designation indicates a federal listing as endangered.

Of the five listed fish species only the Pallid Sturgeon is a federally listed endangered species. Among the factors suspected of contributing to its decline: loss of longitudinal connectivity (i.e., low head diversion dams) and possibly altered hydrology primarily due to water development. With respect to altered hydrology, the issue of the adequacy of FWP's instream reservations to protect pallid sturgeon and other native species was raised in FWP's 10-year report to DNRC on the agency's instream flow reservation (see Chapter VI – Water Administration) for the Yellowstone River. At this point, the pallid sturgeon's instream flow requirements for the Yellowstone River remain undetermined.

There is also concern that even if FWP's instream flow reservation provide adequate protection, that future appropriations that are senior in priority date to the instream reservations such as: Conservation District Water Reservations, Crow and Northern Cheyenne Reserved Water Rights, and Wyoming water development under the Yellowstone River Compact, could still threaten the Pallid Sturgeon. Also, the likelihood of negative impacts to Pallid Sturgeon increases as water development continues while the supply decreases, becomes more variable and/or the hydrograph shifts or changes shape due to climate change.

In addition to fish, two bird species stand out - the Least Tern (Endangered) and Piping Plover (Threatened). These shorebirds use the Yellowstone and Missouri Rivers for breeding and nesting habitat. Their preferred habitat is sparsely vegetated sandbars along rivers or lakes and reservoir shorelines. The significant decline of these bird species is thought to be directly related to the current operation of the water storage system and the elimination of their habitat. The large reservoirs formed by the six dams on the Missouri River and Yellowtail Dam on the Bighorn River in the Yellowstone have greatly changed the character of these rivers by reducing the higher spring flows necessary for creating sandbar nesting habitat and raising summer flows that would, under natural circumstances, be low enough to keep tern and plover nests dry during the rearing season.



STATE WATER-USER PROFILE

The FLOATING ISLANDS of Fish Fry Lake

WRITTEN BY AL KESSELHEIM, PHOTOS BY THOMAS LEE

For a guy with a passion to work on water-related issues, Bruce Kania has a pretty unbeatable perch on the world. His place, near Shepherd, sits 100 feet above the Yellowstone River, between Huntley Diversion and Pompey's Pillar. From his house the view spreads downstream over cottonwood floodplain, sandstone escarpment, looping river valley; a view that triggers images of buffalo herds and teepee encampments, or of Capt. Clark and dugout canoes heading for St. Louis.

What Kania didn't know when he brought the farmland in 1999 with money he'd made selling licenses on a couple of his inventions, was that he was inheriting a place with less than inspiring water quality. Soon after he moved in, he noticed that his black lab would emerge from a pond he'd dug near the house colored almost red and stinking so bad you couldn't get within fifty feet.

The pond was filled mostly with water diverted from the Billings Ditch, an irrigation system that starts some seventy miles upstream.

"I'm no scientist," Kania admits, "but it became my mission to do something about the water quality on my property before it drained into the Yellowstone."

In fact, Kania graduated from the University of Wisconsin with a degree in Social Studies in 1976.

"Two days after graduating, I came to Montana," Kania says. He's stayed here ever since, and what he's been doing lately is working on solutions to water quality issues on his property, and now around the world.

Kania may not be a scientist, but he's smart and creative and knows how to find resources. "Back then, there were people at MSU-Bozeman who were doing some remarkable work with this stuff called biofilm," Kania remembers. "I got talking to them about what I might do to clean up my water."

That investigation led Kania to the phenomenon of floating islands, which exist naturally and act as tremendously efficient water purifiers and provide very productive aquatic habitat in the bargain.

"There are some fantastic examples in the Chippewa Flowage in northern Wisconsin," says Kania. "Some of these islands of vegetation are huge. They support entire forests, gravel beds, and develop rich habitat for an abundant fishery."

Kania has a mind always noodling with ideas, hence his success as an inventor. He started grappling with possibilities of mimicking the floating island phenomenon on his own property.

It's a long story, with the dead ends and failures typical of such quests, along with some breakthrough moments with grants and contracts, but what Kania eventually succeeded with rests on mats of shredded recycled plastic. Buoyancy is provided by foam tubes, and later, by the natural biogas bubbles emitted by biofilm and vegetation, just as in the case of natural floating islands.

From that initial concept and an endless tweaking of materials, design, manufacture, and installation techniques, Kania's idea has morphed into an amazing repertoire of applications.

One of his first contracts involved a U.S. Army Corps of Engineers project to create nesting habitat for terns. His technology furnished a 40,000 square foot island supporting 40,000 tons of sand and gravel. Floating islands are now treating sewage in Singapore, stabilizing ocean coasts against wave action, and being installed to clean water and provide productive habitat from New Zealand to Florida.

His property along the banks of the Yellowstone River continues to serve as his working laboratory and the testing ground for Kania's inventive imagination, which encompasses everything from fish fertilizer to reusing shredded carpet fibers.

Near one end of his infamous pond, which he has named Fish Fry Lake, Kania has constructed an elaborate dock. In typical fashion, Kania says, "I needed a dock. I might as well put it to work."

Putting it to work involved constructing an underwater concrete viewing room with a window eleven feet below the lake surface, building an extensive array of floating islands supporting the dock while also providing filtration and habitat functions, and adding an elevated 'streambed' that aerates water along an artificial channel on top of a long section of floating mat.

Kania boasts that Fish Fry Lake has gone from a body of water his dog emerged from as a living symbol of pollution, to the "most productive fishery in Montana." It has also gone from a reeking chemical stew to a state approaching natural balance and aerobic function from top to bottom.

"In recent tests we found no detectable levels of nitrogen and phosphorus cut in half," Kania reports.

More important, from Kania's point of view, is the potential for broad application of his floating island technology.

"We are very committed to Montana," says Anne Kania, Bruce's wife and business partner.

"So many of our problems come back to sick water," adds Kania. "I'm developing small floating islands that can be dropped into puddles and ponds to mitigate everything from mosquito and midge infestations to West Nile and hemorrhagic disease in deer populations."

"This is a vision of hope," emphasizes Kania. "It's a vision of abundance. We've been in a long downward spiral of water quality in this country, but we can reverse that. We know how to do it right now." ■

"I'm no scientist, but it became my mission to do something about the water quality on my property before it drained into the Yellowstone."

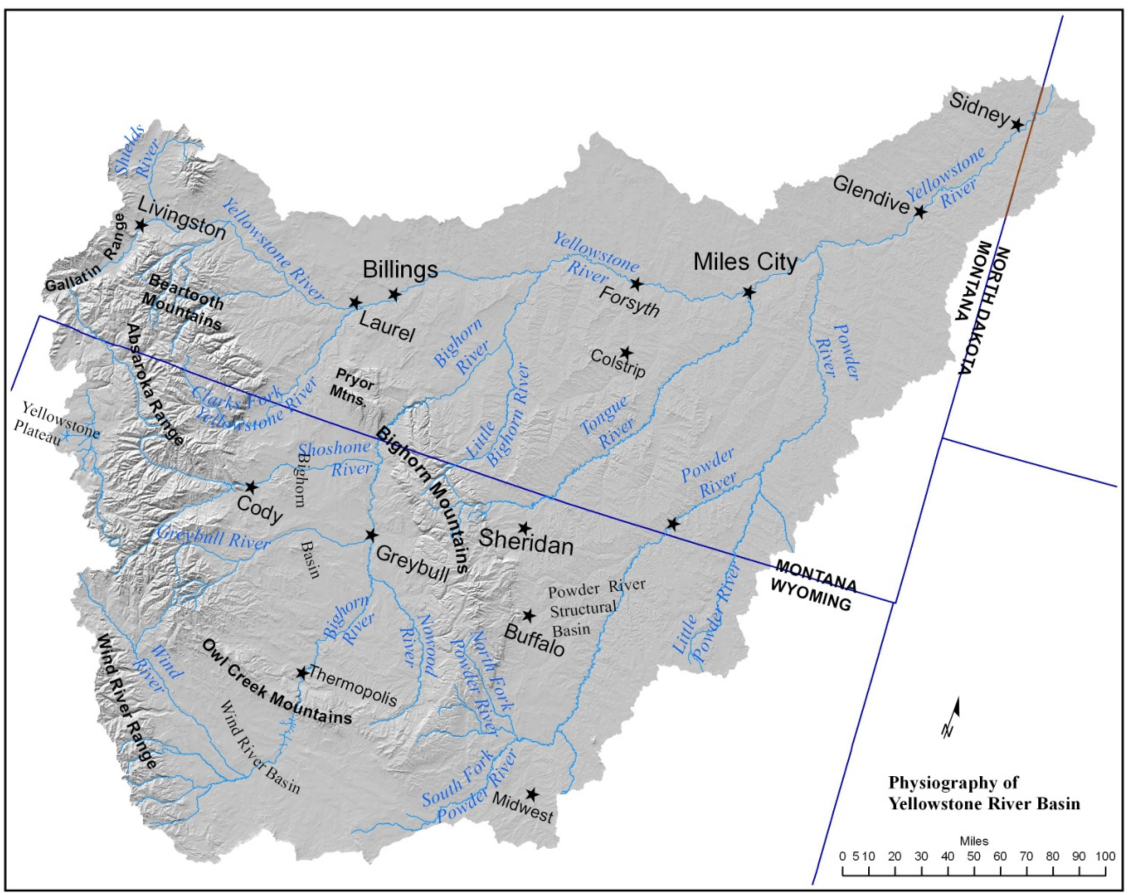
—Bruce Kania

IV. Water Resources in the Yellowstone River Basin

Physiography

The Yellowstone River is the longest free-flowing river in the lower 48 states and drains about 70,000 square miles as it flows more than 700 miles from its origin in Yellowstone National Park to the confluence with the Missouri River in North Dakota (Figure IV-1). The Yellowstone River main stem flows into Montana near Gardiner on the southern edge of the park. Several large tributaries, including the Clarks Fork Yellowstone River, Bighorn , Tongue and Powder Rivers also originate in Wyoming and flow north to join the main Yellowstone River in Montana (Figure IV-1—Table IV-1, Figure IV-4). Elevations in the drainage basin range from about 13,780 feet in the mountains south of Yellowstone National Park to 1,850 feet at the mouth of the Yellowstone River (Zelt and others, 1999).

Figure IV-1 Physiography of Yellowstone River Basin -- Major Mountain Ranges and Runoff Producing Areas.



Geology

The Yellowstone River Basin contains parts of three geologic provinces: the uplifts and basins of the Rocky Mountain foreland, the Yellowstone plateau, and the Absaroka volcanic field (Snoke, 1993; Zelt et al., 1999). In the upper Yellowstone River sub-basin, the tributaries were generally formed by erosion by streams and glaciers, and are mostly narrow with thin strips of shallow alluvium. In contrast, the larger intermontane basins, such as Paradise valley (Figure IV-2), 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. Shallow sediments in the intermontane basins of the upper Yellowstone River sub-basin consist of Quaternary alluvial fans, glacial outwash and till, and floodplain alluvium. These sediments are generally less than 150 feet thick but are thicker in some locations. Bedrock units in the upper Yellowstone River sub-basin, include metamorphic and igneous rocks as well as clastic and carbonate rocks of various ages.

Figure IV-2 Paradise Valley and Upper Yellowstone River south of Livingston, Montana

A thick sequence of sedimentary rocks of Tertiary age unconformably overlies the eroded Cretaceous surface in most of the plains and basins. Tertiary sedimentary rocks consist mainly of sandstone, siltstone, and claystone, with interbedded coal and lignite. Tertiary sedimentary rocks are exposed over about 43 percent of the Yellowstone River Basin, and Tertiary volcanic rocks are exposed over nearly 8 percent (Zelt and others, 1999). In the Powder River sub-basin, sediment shed from the adjacent Laramide uplifts of the Big Horn and Pryor Mountains were transported and deposited primarily by fluvial processes (Curry, 1971).

Surficial bedrock geology in the middle Yellowstone River sub-basin includes the Upper Cretaceous to lower Tertiary rocks of the Eagle Sandstone, Claggett Shale, Judith River Formation, Bearpaw Shale, Fox Hills Formation, and Hell Creek Formation, and the Tullock Member, Lebo Member, and Tongue River Member of the Fort Union Formation. Where the Yellowstone River crosses eroding shale, the valley is on the order of miles wide. Where the Yellowstone River encounters resistant sandstone the river valley narrows to less than a quarter mile in some places.

Surficial bedrock geology in the lower Yellowstone River sub-basin includes the Upper Cretaceous to lower Tertiary rocks of the Bearpaw Shale, Fox Hills Formation, and Hell Creek Formation, and the Tullock Member, Lebo Member, and Tongue River Member of the Fort Union Formation. Inland seas periodically covered the lower Yellowstone during geologic time. Streams carried mud and sand into these seas, and the mud and sand deposited during the last marine inundation now make up the Bearpaw Shale and Fox Hills Formations, respectively. When the seas receded, streams continued to carry sediment into the basin. When the last sea receded from what is now Montana, streams deposited sand and mud that later became the Hell Creek Formation and Fort Union Formation (Smith et al., 2000). Near the western extent of the lower Yellowstone River sub-basin, stresses associated with mountain building uplifted rocks along two smaller structures: the northwest-- southeast–oriented Cedar Creek Anticline and Poplar dome. Regional uplift of the Great Plains and Rocky Mountain area and drainage adjustments, resulting from glaciation, caused streams to downcut and develop the modern landscape of broad valley floors and low-relief uplands (Smith et. al., 2000).

The Yellowstone River basin contains numerous faults, crustal folds, arches and troughs that buckled the rocks underneath the plains. These structures may exist sub-regionally and locally and consist of geologic folds and fault/fracture zones that play a role in defining the limits of groundwater boundaries in the Yellowstone River basin. These features can be either barriers to, or pathways for, groundwater flow. Faults that are barriers have the type of displacement that grinds up rock and creates very low permeability fault gouge along the fault plane, isolating the aquifers on each side. Additionally, faults with significant vertical displacements may offset aquifers on each side of the fault. Significant water level differences have been identified in wells near such hydrostructures in the Yellowstone River basin (e.g., in the Bull Mountain aquifer system). Folds and their associated faults can create linear zones of low permeability that affect the lateral continuity of groundwater flow in aquifers.

The distribution and physical properties of geologic units affect the availability, movement, and quality of groundwater. The geologic units in eastern Montana that contain usable groundwater are unconsolidated alluvial and terrace deposits within the major stream valleys and the sedimentary strata that lie above the Claggett Shale. Deep regional aquifers are present beneath the Claggett Shale, however water in these aquifers is too saline to be used as a potable supply or for irrigation.

The contemporary physical characteristics and geomorphology (channel slope, cross-sectional shape, and floodplain width) of the Yellowstone River and its floodplain are influenced by the distribution of bedrock types, faulting and folding, glacial history of the drainage (especially in the upper segments between Gardiner and Springdale), and the recent (past 60 years) human intervention ranging from flow regulation (Yellowtail Dam) to channel modification (riprap, dikes, levees). The physical characteristics of the channel and floodplain strongly influence biological attributes such as riparian vegetation, fish and wildlife habitat (Boyd and Thatcher 2008; Dalby and Robinson, 2014).

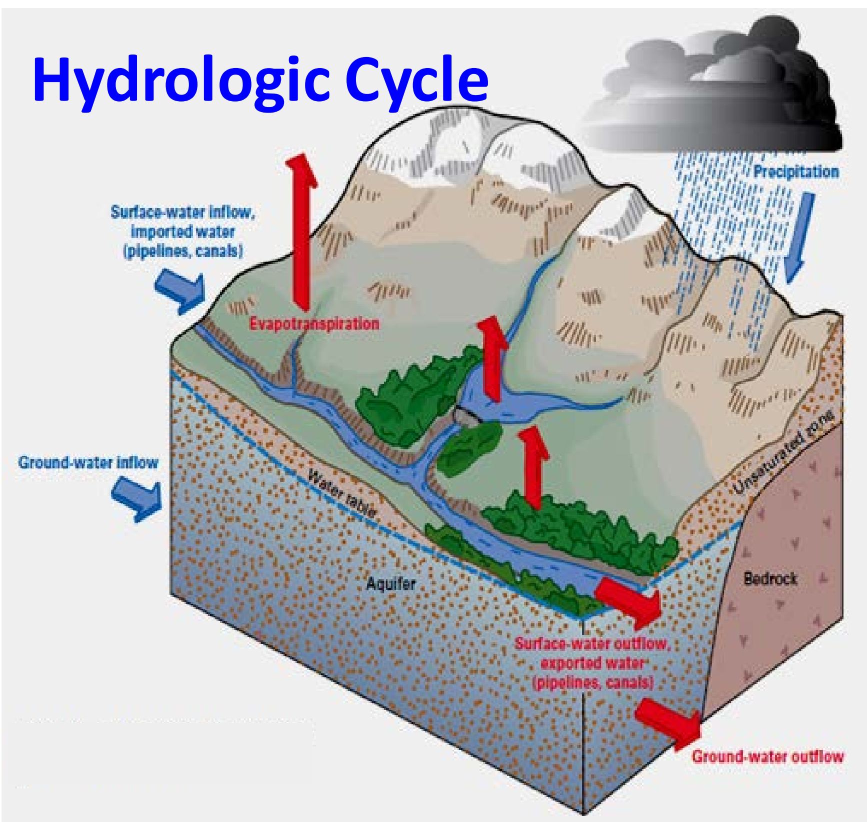
Hydrography

The diverse physiography of the Yellowstone River Basin is an important factor in determining surface water hydrology. From its headwaters at the Continental Divide in northwestern Wyoming, the Yellowstone River flows out of the mountains and across the plains of south-central and eastern Montana to the confluence with the Missouri River in western North Dakota (Figures IV-1 and IV-4). Approximately 80 percent of the runoff (measured near Sidney, Montana), originates in the mountains of Wyoming and enters Montana from the four major tributary basins: the Clarks Fork Yellowstone, Wind/Bighorn, Tongue, and Powder Rivers. The higher elevations of the Beartooth Mountains, Wind River Range, Absaroka Range, and Bighorn Mountains are the headwaters of most of the perennial streamflow in the basin (Wahl, 1970).

Basin relief is large; headwaters elevations exceed 13,000 feet above sea level for streams originating in the mountains, while the mouth (where it joins the Missouri River in North Dakota) of the main stem Yellowstone River is 1,850 feet above sea level. The main stem is more than 700 miles long. The combination of large relief in the mountainous areas and long stream lengths across the basins and plains results in a large range in stream and precipitation gradients for the major tributaries.

Water that originates through snowfall and precipitation is stored in mountain snowpack and watershed soils and is consumed through evaporation and transpiration (Figure IV-3). Some water is stored as groundwater in aquifers, and later recharges fall and winter base flow.

Figure IV-3 Hydrologic cycle for a part of a watershed.



Sub-basins

The Yellowstone River basin has been sub-divided into 23 hydrologic units by the USGS (in cooperation with other federal, state, and public entities) (Figure IV-4) for the purposes of measuring and monitoring streamflow, water quality, and other natural resource attributes. For the state water plan, these hydrologic units (HUC's) were aggregated into upper, middle, and lower basins for information presentation and analysis (Figure IV-4). The location of stream gaging stations and drainage basin characteristics, for the water-planning units, are given in Table IV-1.

The Upper Yellowstone sub-basin extends from the headwaters in Yellowstone National Park to Billings, Montana. In addition to receiving flow, mainly in the form of snowmelt from the headwaters, the main stem

Yellowstone receives runoff from mountain tributaries in the Paradise Valley upstream from Livingston; the Shields, Boulder and Stillwater Rivers contribute a smaller amount. The Clarks Fork Yellowstone River, which drains the Beartooth Plateau in Wyoming, enters the main stem approximately 13 miles upstream from Billings and contributes significant runoff. The Upper Yellowstone Basin contains minor dams and reservoirs that do not significantly influence annual runoff.

The Middle Yellowstone sub-basin extends from Billings to Miles City, and receives most additional flow from the Bighorn River, which enters the main stem approximately 50 miles downstream from Billings; other tributaries including Pryor Creek, Rosebud Creek, Porcupine Creek and the Tongue River, contribute less flow. The Middle Yellowstone sub-basin contains a significant number of storage projects including Yellowtail Dam (located in Montana) and Bighorn Lake (located primarily in Wyoming). Three other large reservoirs in Wyoming influence the flow of the Bighorn River and Yellowstone main stem in Montana—Boysen, Buffalo Bill and Bull Lake Reservoirs. The Tongue River Dam and Reservoir, located about 15 miles south of the Wyoming state line, influences the seasonal distribution of streamflow in the Tongue River, but has little effect on main stem river flow.

The Lower Yellowstone sub-basin extends from Miles City to Sidney, Montana and drains a semi-arid plain. With the exception of the Powder River, streams entering the main stem Yellowstone are primarily intermittent and contribute little streamflow. Streamflow in the Powder River is generated almost entirely by snowmelt runoff from tributaries that drain the eastside of the Bighorn Mountains in Wyoming—Clear Creek, Crazy Woman Creek, and the Middle Fork Powder River.

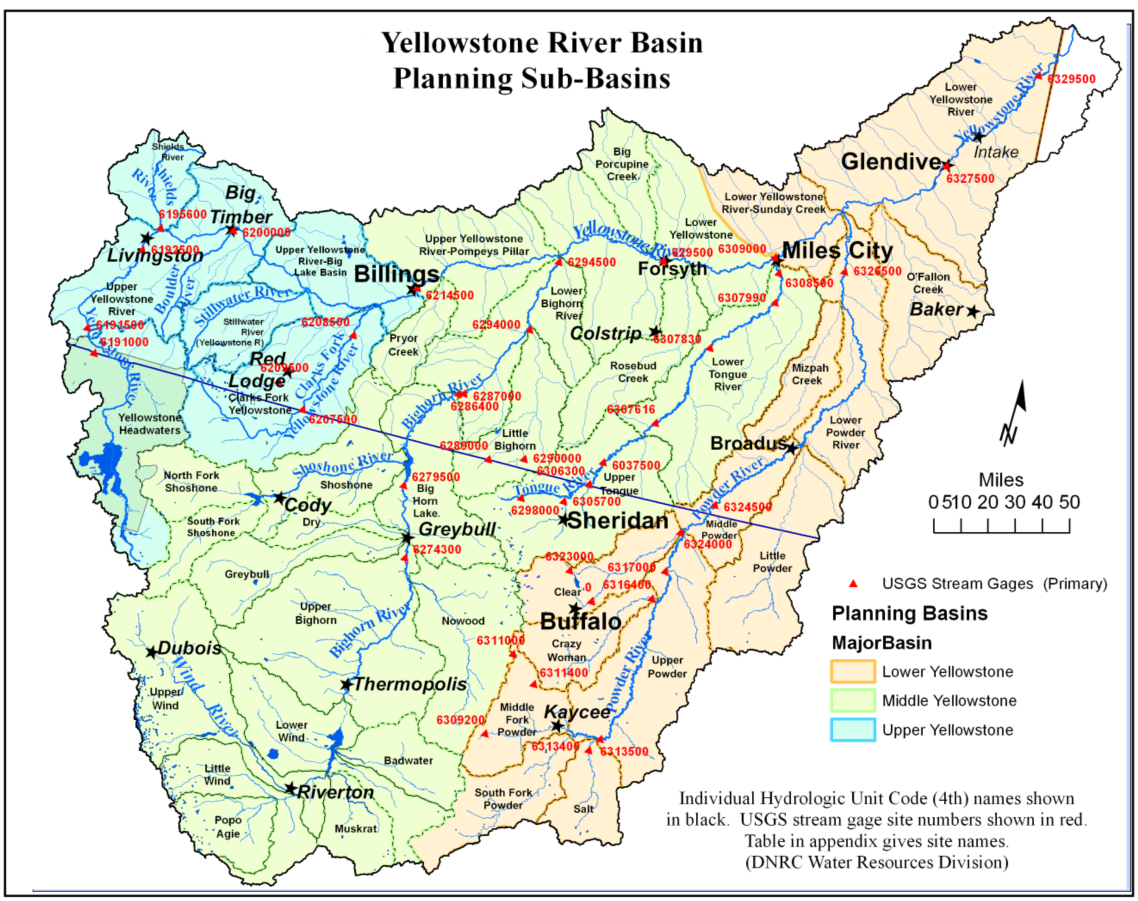
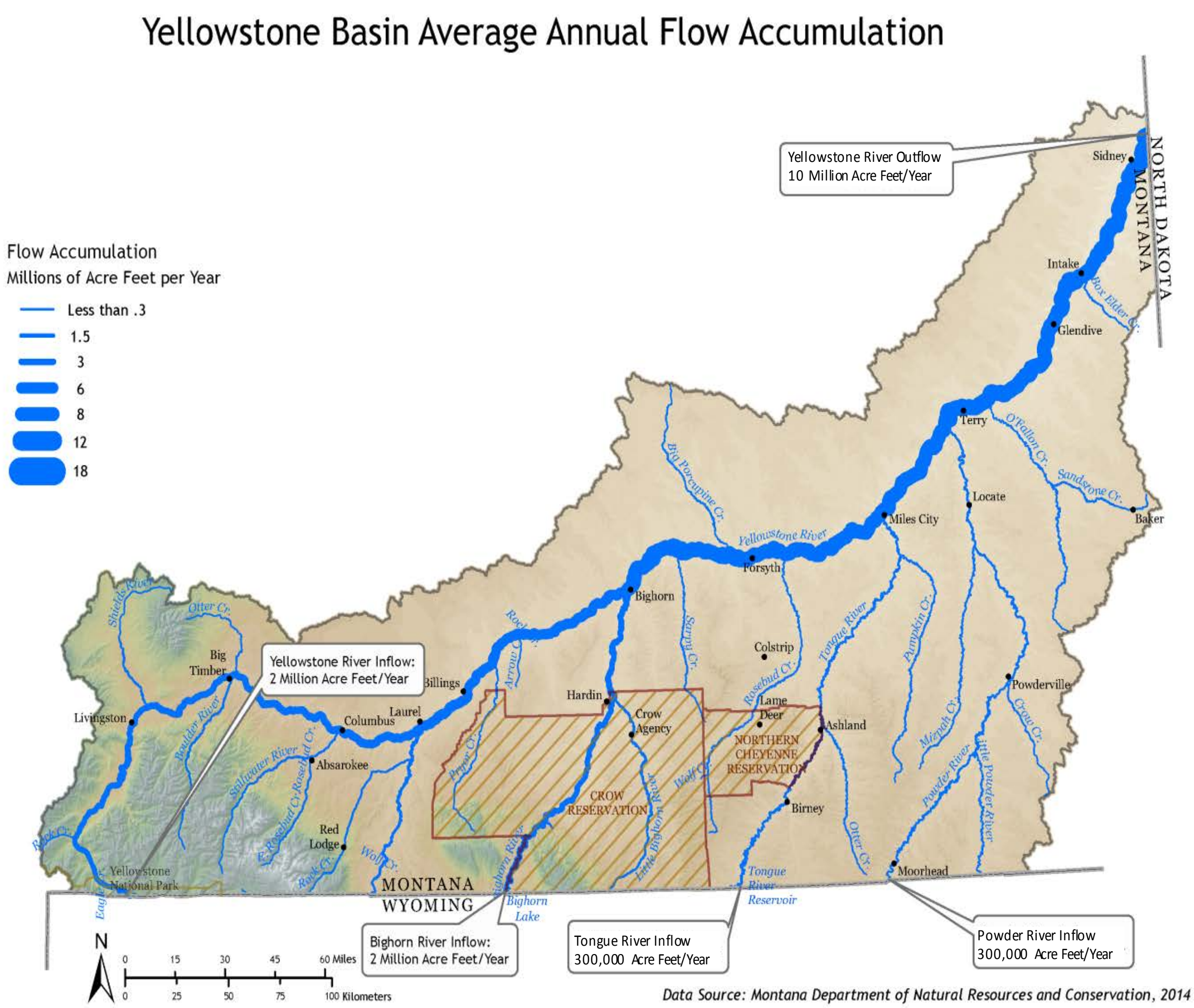


Figure IV-4
Yellowstone River Sub-basins Aggregated into Upper, Middle and Lower Water-Planning Basins.

Table IV-1 Yellowstone River Basin: MWSI Sub-basin Divisions and Streamflow Information

Yellowstone River Mainstem Location	Tributary of Yellowstone River	USGS Station ID	Basin Area (mi^2)	Percent of Total Basin Area	Period of record of Annual, Monthly, and Mean-Daily Discharge	Hydrologic Conditions Analyzed by USACE and USGS	MTDEQ TMDL Planning Unit
Yellowstone River at Yellowstone Lake Outlet, Yellowstone National Park, Wyoming		6186500	991	1.43450632	1922-82, 1983-86, 1988-2010	historic	
Yellowstone River at Corwin Springs		6191500	2619	3.79109187	1930-2011	historic, regulated, and unregulated flow conditions (monthly historic 1928 to 2002) USACE Sept 2011)	Upper Yellowstone Sub-Basin
Yellowstone River near Livingston		6192500	3551	5.14019368	1930-2011	historic, regulated, and unregulated flow conditions (monthly historic 1928 to 2002) USACE Sept 2011)	
Yellowstone River at Billings		6214500	11805	17.0881404	1930-2011	historic, regulated, and unregulated flow conditions (monthly historic 1928 to 2002) USACE Sept 2011)	
	Bighorn River above Tullock Cr near Bighorn, Mont	6294500	22414	34	1945-55, 1956-2010	regulated and unregulated flow conditions (monthly 1928 to 2002) USGS 2013	
Yellowstone River at Forsyth		6295000	40146	58	1977-2011	regulated and unregulated flow conditions (monthly 1928 to 2002) USGS 2013	
	Tongue River at State Line near Decker, Mont.	6306300	1,453	2	1960-2010	regulated and unregulated flow conditions (monthly 1928 to 2002) USGS 2013	Middle Yellowstone Sub-Basin
	Tongue River at Tongue River Dam near Decker, Mont.	6307500	1,770	3	1939-2010	regulated and unregulated flow conditions (monthly 1928 to 2002) USGS 2013	
	Tongue River at Miles City, Mont.	6308500	5,397	8	1938-42, 1946-2010	regulated and unregulated flow conditions (monthly 1928 to 2002) USGS 2013	
Yellowstone River at Miles City		6309000	48253	70	1930-2011	regulated and unregulated flow conditions (monthly 1928 to 2002) USGS 2013	
	Powder River at Moorhead, Mont.	6324500	8,086	12	1929-72, 1974-2010	regulated and unregulated flow conditions (monthly 1928 to 2002) USGS 2013	
	Powder River near Locate, Mont.	6326500	13,068	19	1938-2010	regulated and unregulated flow conditions (monthly 1928 to 2002) USGS 2013	Lower Yellowstone Sub-Basin
Yellowstone River at Glendive		6327500	66739	97	1930-2011	regulated and unregulated flow conditions (monthly 1928 to 2002) USGS 2013	
Yellowstone River near Sidney		6329500	69083	100	1930-2011	regulated and unregulated flow conditions (monthly 1928 to 2002) USGS 2013	

Figure IV-5 Yellowstone River Basin: Average Annual Flow Accumulation in Montana Portion of Basin.



Much of the runoff produced in the Yellowstone River Basin originates in the headwaters of the upper basin in the Wind River, Absaroka, Beartooth, and Big Horn Mountains (Figure IV-5). Transboundary inflow from Wyoming into Montana includes about 2 million acre-feet per year in the upper Yellowstone River (near Gardiner, Mt.), 2 million acre-feet from the Bighorn River, 200,000 acre-feet from the Tongue River and 300,000 acre-feet from the Powder River. Additional runoff is provided from the Clarks Fork (about 700,000 acre-feet), Rock Creek (about 100,000 acre-feet) and Little Bighorn (160,000 acre-feet). Most runoff generated within Montana comes from headwater tributaries draining the Absaroka and Beartooth Mountains: Boulder River (350,000 acre-feet) and Stillwater River (950,000 acre-feet). Much less runoff is contributed by the Yellowstone tributaries entering from the north, with the Shields River (190,000 acre-feet) providing the most. Other prairie streams, for example Big Porcupine Creek near Forsyth and Sunday Creek near Miles City provide less than 30,000 acre-feet per year to Yellowstone River flow. The 1981-2010 mean-annual discharge of the Yellowstone River near Sidney Montana is about 7.7 million acre-feet. This recorded flow is an amount depleted by all upstream consumptive uses of water in Wyoming and Montana. The annual, basin-wide estimated depletions of water by consumptive use, approximately 1.9 million acre-feet per year, added to the recorded streamflow, provides an un-depleted (“natural”) flow estimate of about 10 million acre-feet per year of flow leaving the state at the North Dakota border.

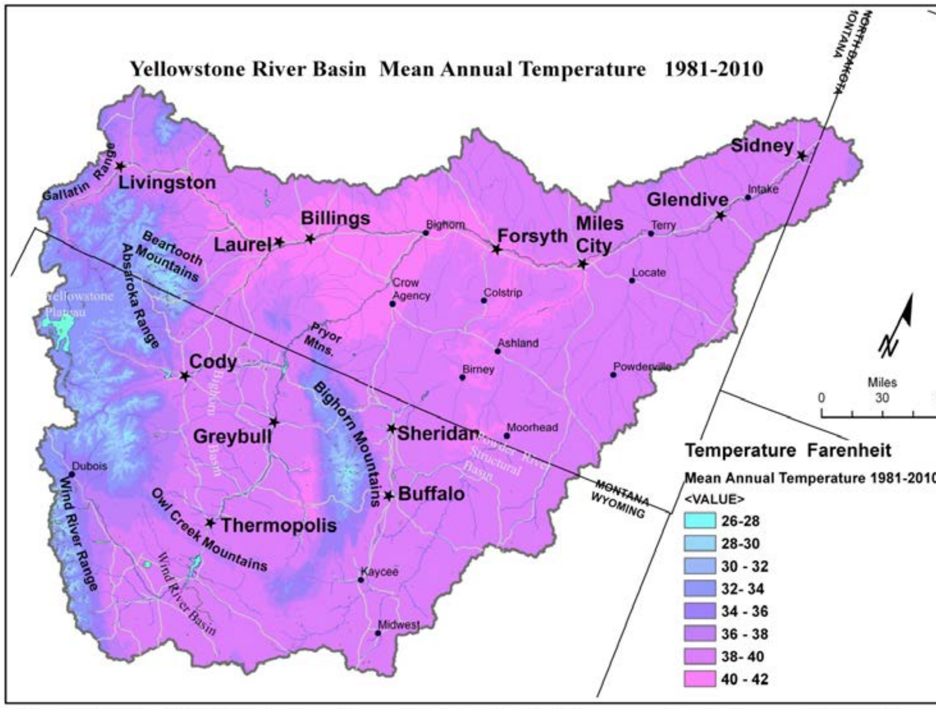
Climate

Climate in the Yellowstone River Basin ranges from cold and moist in the mountainous areas to temperate and semiarid in the plains areas. Primarily because of its midcontinent location, the basin's weather is characterized by fluctuations and extremes (Missouri Basin Interagency Committee, 1969). Interaction between air masses originating in the Gulf of Mexico, the northern Pacific Ocean, and the Arctic regions is largely responsible for the seasonal climate regimens found within the study area. Gulf air tends to dominate in spring and early summer, but Arctic air dominates in winter (Missouri Basin Interagency Committee, 1969).

Mean annual temperatures range from less than 32°F at Yellowstone Lake to about 50°F along the Bighorn River valley in Montana (National Climatic Data Center, digital data, 1994). Annual temperature extremes range from about -40°F during the winter to hotter than 100°F during the summer (Western Regional Climate Center, digital data, 1997). Temperatures generally are coldest in January, when average daily lows range from less than -0.4°F in higher elevations to about 18°F near Livingston, Mont. (Western Regional Climate Center, digital data, 1997), and average monthly temperature ranges from less than 9°F in Yellowstone National Park to about 27°F near Livingston, Mont. (National Climatic Data Center, digital data, 1994). July normally is the warmest month, with average daily highs ranging from about 72°F in higher elevations to about 90°F in some valleys of the Great Plains and Wyoming Basin (Western Regional Climate Center, digital data, 1997). Average July temperature ranges from about 54°F in higher elevations to about 75°F in some valley locations (National Climatic Data Center, digital data, 1994). The average frost-free period ranges from less than 10 days at high elevations (Marston and Anderson, 1991) to more than 140 days on the plains and in lower basins (U.S. Department of the Interior, 1965). The climate is cold enough at some sites to form permanent ice (permafrost) in the ground: local permafrost occurs at elevations as low as 7,900 to 8,500 feet on north slopes near Yellowstone National Park (Pierce, 1979). Mean-annual temperature for the Yellowstone Basin for the period 1981-2010 is shown in Figure IV-6.

In the Yellowstone River Basin, 40 to 45 percent of the annual precipitation falls during April through June at most locations, but this seasonality diminishes in mountainous areas. Mean annual precipitation ranges from more than 70 inches at high elevations in the mountains near Yellowstone National Park (PRISM Climate Group OSU, 2014) to 5.5 inches in the central parts of the Bighorn and Wind River Basins (Figures VI-4 and Snowfall composes a substantial part of annual precipitation in most years, with average annual snowfall ranging from less than 12 inches in parts of the Bighorn Basin to more than 200 inches near Yellowstone National Park. The mountain ranges in the study unit cause precipitation to vary strongly with elevation, because most of the spatial variation in precipitation is explained by orographic effects. (Daly and others, 1994). Annual precipitation in the plains areas generally is more variable from year to year, and is much less than in the mountains (Figures IV-8 and IV-9—additional temperature and precipitation data are provided in Appendix C, Section IV). Mean-annual precipitation for the Yellowstone Basin for the period 1981-2010 is shown in Figure IV-7.

Figure IV-6 Yellowstone River Basin Mean Annual Temperature.



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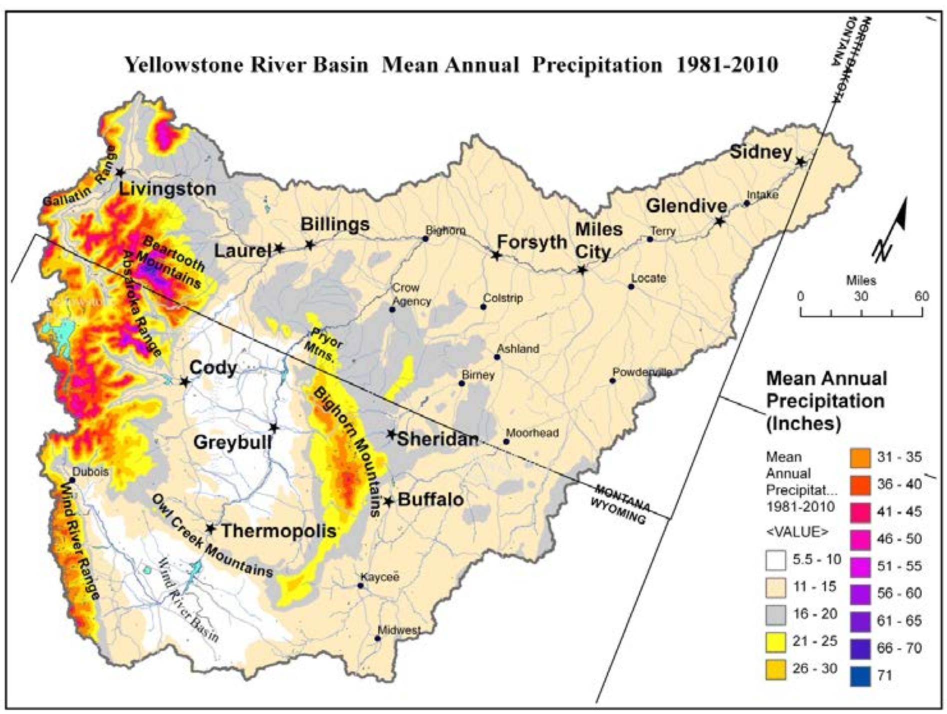
DNRC Water Management Bureau Helena, Montana

Figure IV-7 Yellowstone River Basin Mean Annual Precipitation.



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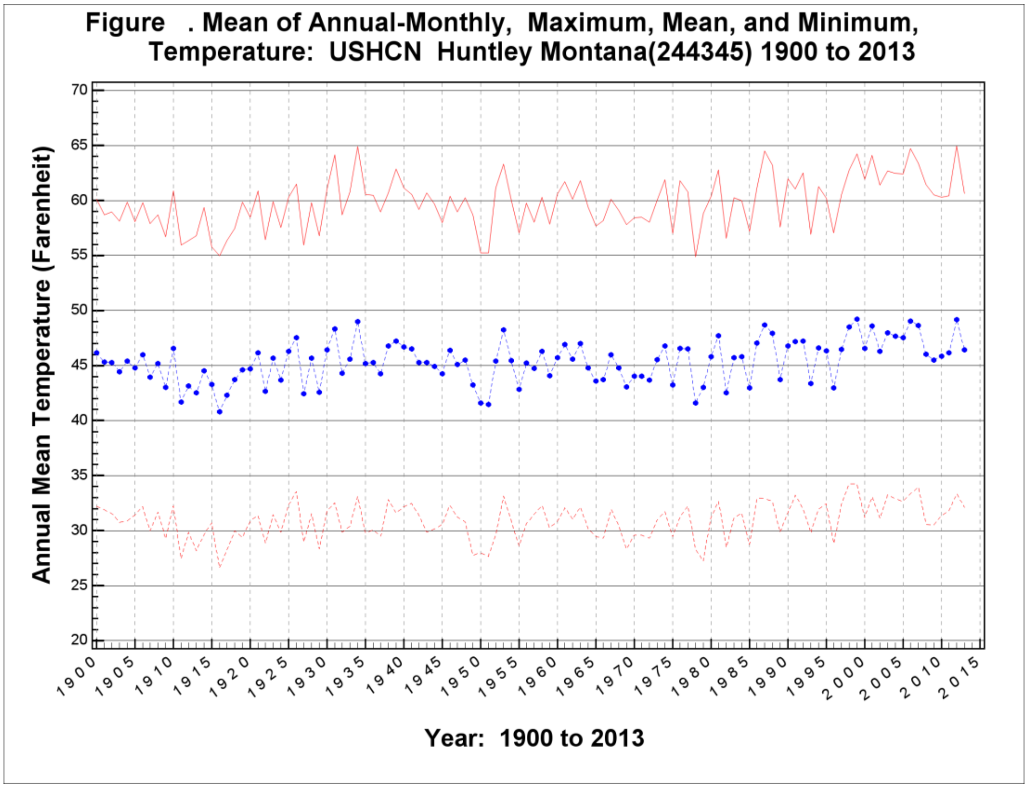
DNRC Water Management Bureau Helena, Montana

Figure IV-8 Huntley, Montana: Annual Temperature (1900-2013) and Annual Precipitation (1896-2013; dashed lines represent averages for different periods).



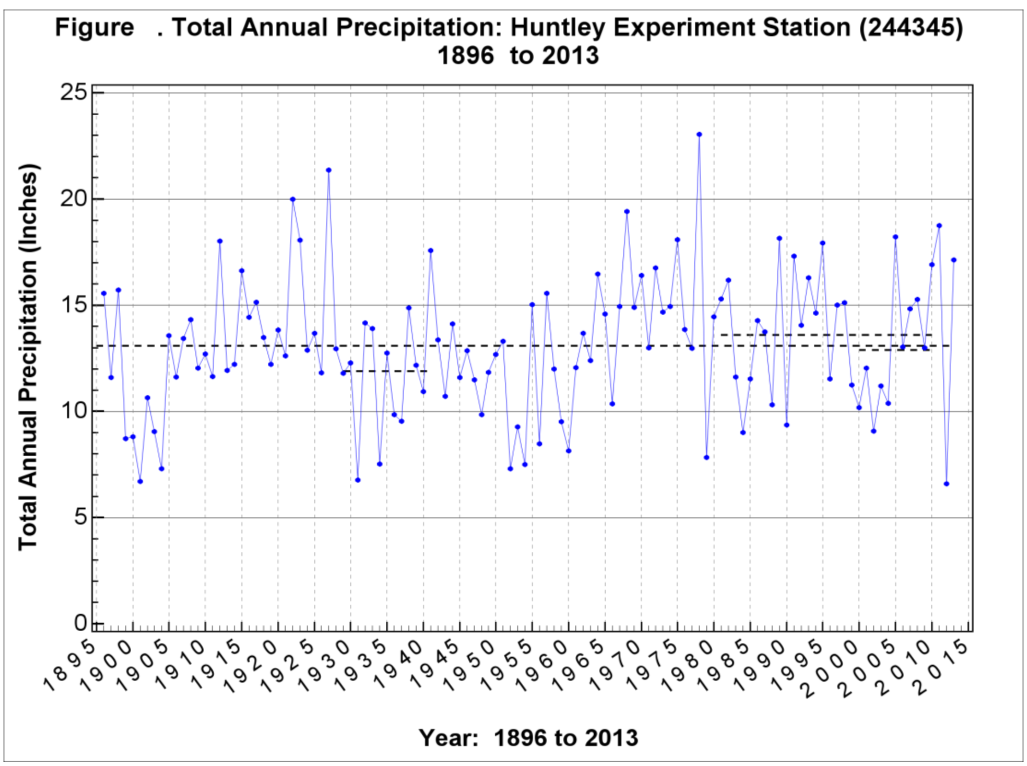
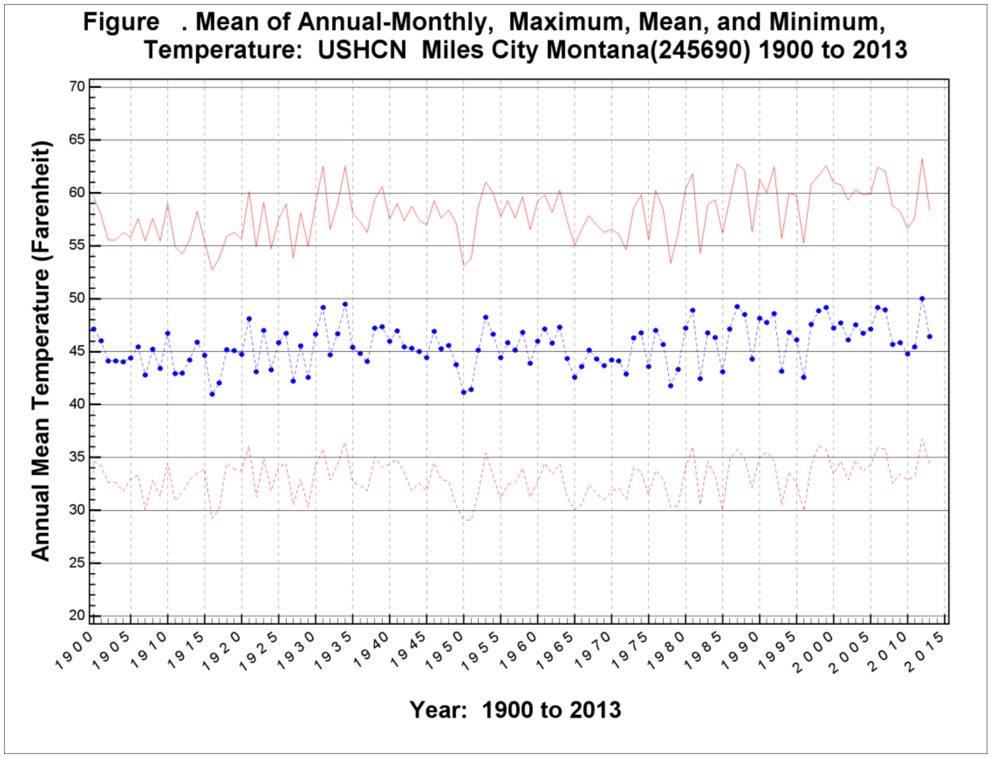
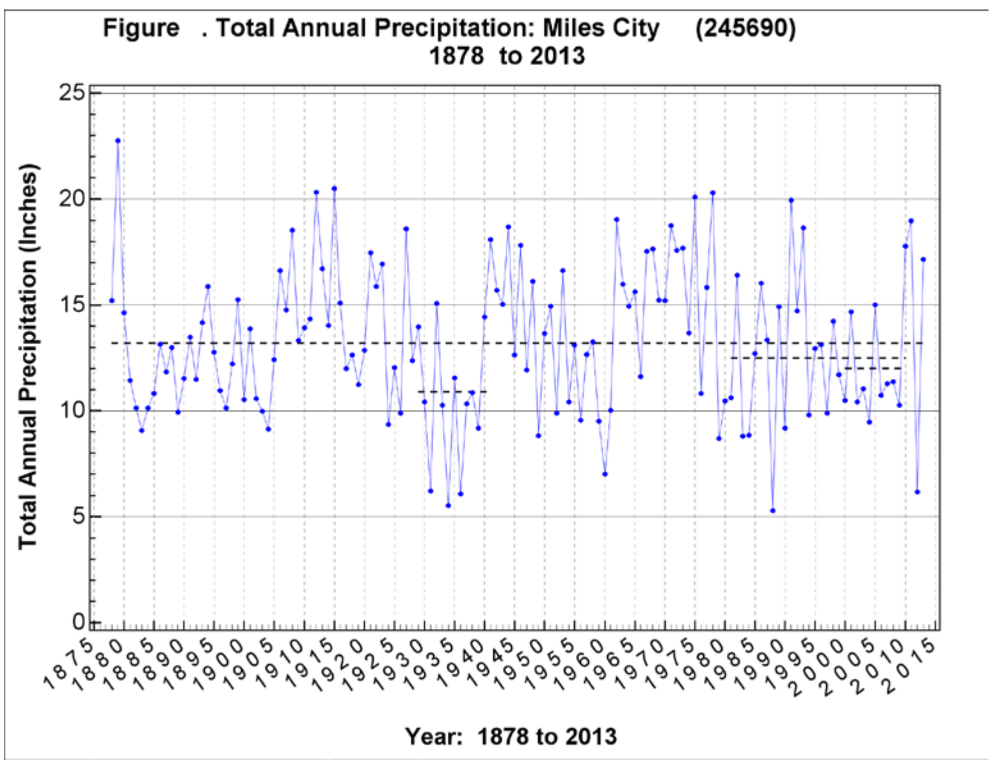


Figure IV-9 Miles City, Montana: Annual Temperature (1900 to 2013) and Annual Precipitation (1878-2013; dashed lines represent averages for different periods).





Snowpack and Variation in Water Supply

Snowfall is the primary source of runoff to the Yellowstone River. High-elevation areas in the mountainous headwaters of Wyoming and Montana store water from October through May. This water is released in April through August, with most runoff occurring in the spring-summer snowmelt flood that typically peaks in mid to late June. Lower elevation snow accumulation may runoff during February through March and create a “double-peaked” hydrograph (Figures IV-25—IV-28).

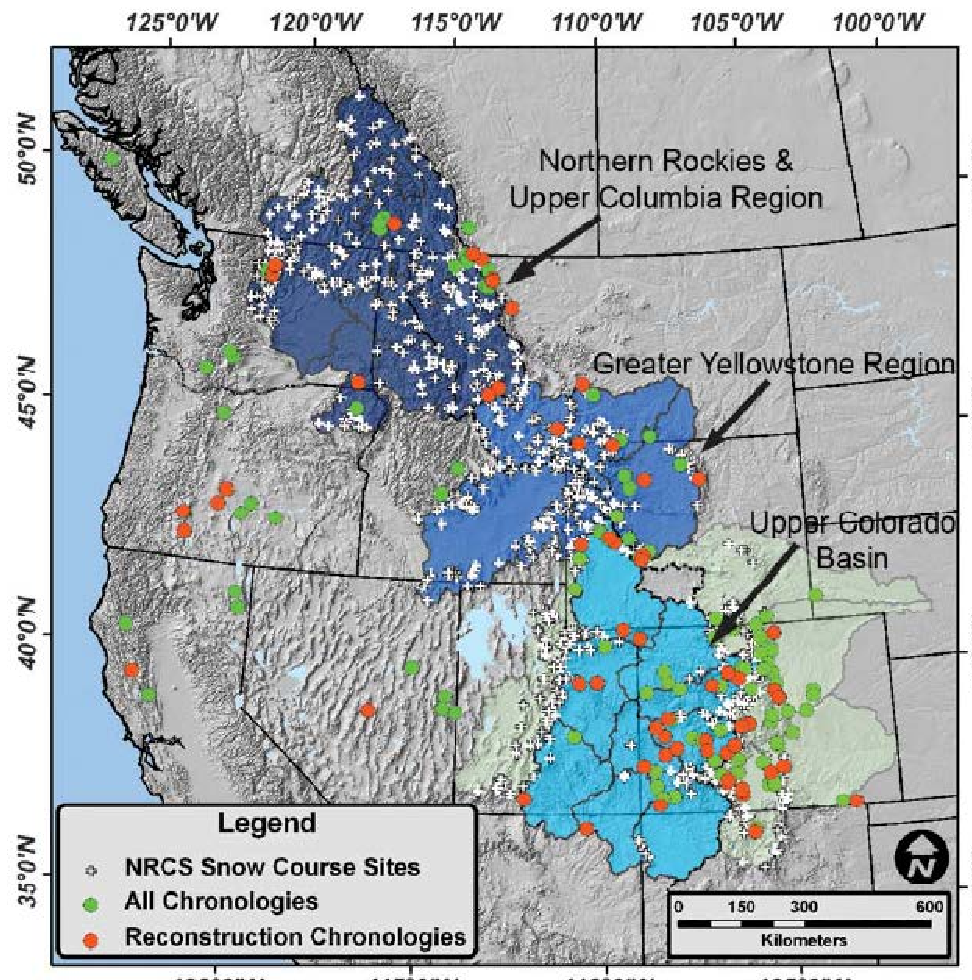
Much of the Yellowstone River Basin has an arid to semiarid climate, and the majority (80 percent or more) of surface water originates as mountain snowpack (Hamlet et al. 2007; Stewart et al., 2005). Snow serves as a natural reservoir for water that is released over the spring (April–June) and summer (July–September) (Pederson et.al., 2011). All consumptive and nonconsumptive uses of water have adapted to this natural pattern of storage and release of water. Fish, wildlife, riparian vegetation, and river channels are adjusted to this pattern of runoff which includes a long-duration, snowmelt flood pulse in the spring and a gradual decline of streamflow over the summer months. From fall through early spring, low flows are maintained by the release of groundwater from aquifers recharged by snowmelt runoff over the spring and summer. Because of the limited reservoir capacity in the Montana portion of the basin, irrigated agriculture is highly dependent on the amount and timing of snowmelt runoff.

A growing number of studies have demonstrated that, since 1950, western North America has experienced a substantial decline in peak snow water equivalent (SWE) (Das et al. 2009; Mote et al. 2005; Pierce et al. 2008) and subsequently a reduced and earlier snowmelt runoff (Aguado et al. 1992; Cayan et al. 2001; Dettinger and Cayan 1995; Hidalgo et al. 2009; McCabe and Clark 2005; Rajagopalan et al. 2009; Regonda et al., 2005) (Figures IV-11 and IV-12). In addition, there is evidence that the higher percentage of precipitation is falling as rain rather than snow (Knowles et al., 2006); the basin is also experiencing an increasing number of low baseflows during dry years (Luce and Holden 2009), and significant increases in the percentage of total annual water discharge occurring during the winter (Das et al. 2009; Dettinger and Cayan 1995; Stewart et al. 2005).

Natural climatic variation, driven by interaction between oceanic processes (e.g. circulation of ocean currents) and atmospheric processes (e.g. creation of jet stream) has a significant effect on short and long-term variation in regional climate, snowpack and runoff. For example, over within-decade to multi-decadal periods of time, seasonal controls on variation in climate and runoff, are strongly influenced by natural ocean–atmosphere interactions (e.g., Cayan 1996; Cayan et al. 1998; Dettinger et al. 1995; Rood et al. 2005), with modifying influences associated with the North Atlantic (e.g., Enfield et al. 2001; McCabe et al. 2004). Variations in sea-surface temperatures substantially alter air temperature and precipitation patterns across large regions (i.e., at sub- continental scales) by modifying atmospheric circulation patterns and consequently changing the preferential positioning of storm tracks (Cayan 1996; Cayan et al. 1998; Dettinger et al., 1995). For the northern Rocky Mountains, the Pacific Decadal Oscillation (PDO) (Mantua et al. 1997) is the dominant interannual-to-decadal-scale index of Pacific basin sea surface temperature variability.

Pederson et al. (2011) assessed the historical variability and trends in the hydroclimatology of snow-dominated watersheds in the Northern Rocky Region (NRM), (Figure IV-10) which includes the Upper Yellowstone and Bighorn Basins.

Figure IV-10 Northern Rocky Mountain Region (including the Upper Yellowstone and Bighorn Basins) Location Long-term Snowcourse and Tree-Ring Chronology Sites (Pederson et.al. 2013).

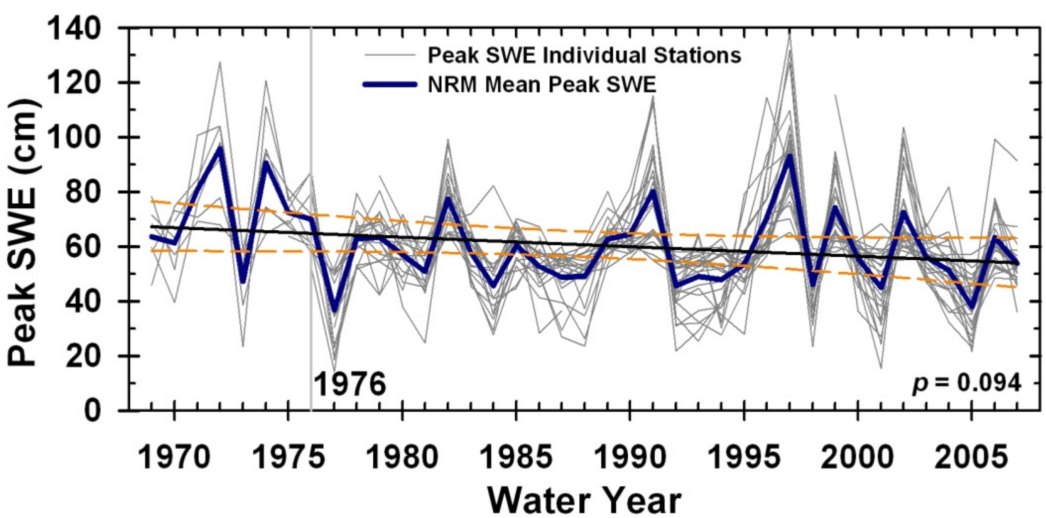


Analyses conducted (using records from 25 snow telemetry (SNOTEL) stations, 148 April 1 snow course records, stream gauge records from 14 relatively unimpaired rivers, and 37 valley meteorological stations) showed that:

- Over the past four decades, mid-elevation SNOTEL records show a tendency toward decreased snowpack with peak snow water equivalent (SWE) arriving and melting out earlier.

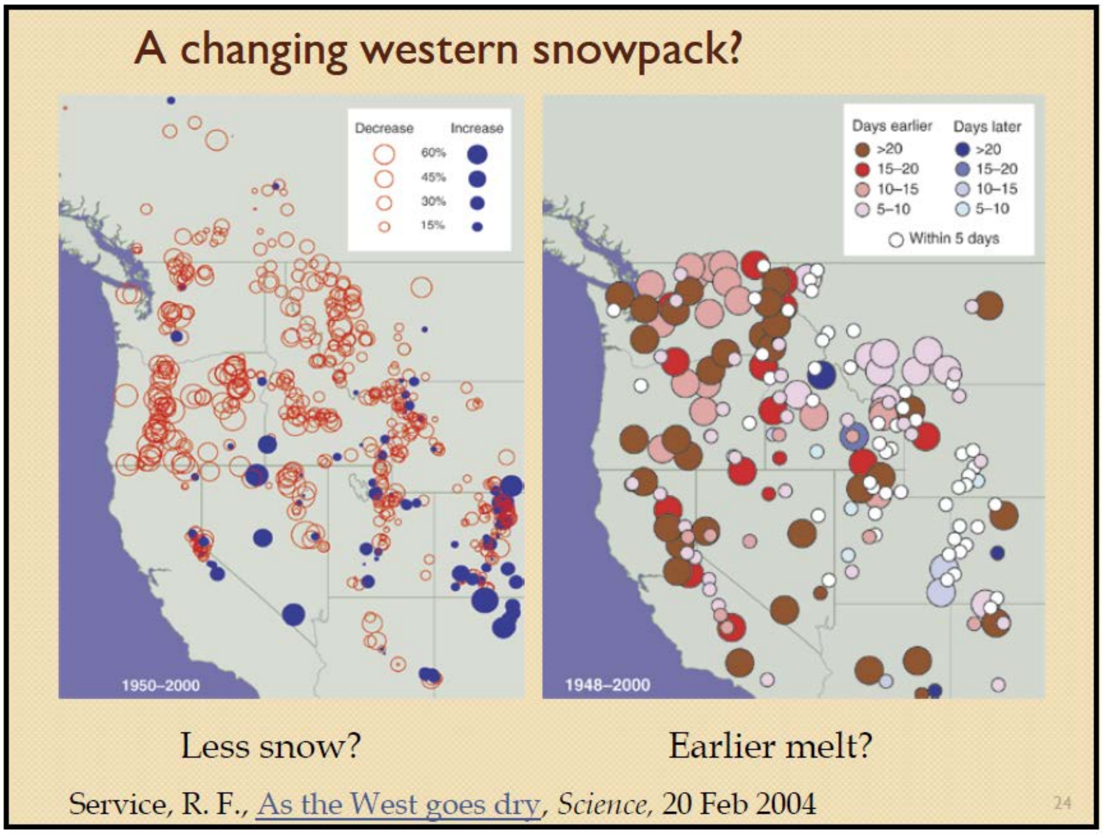
- Temperature records show significant seasonal and annual decreases in the number of frost days and changes in spring minimum temperatures that correspond with atmospheric circulation changes and surface–albedo (solar reflection from snow cover) feedbacks in March and April.
- Warmer spring temperatures coupled with increases variability of spring precipitation correspond strongly to earlier snow melt-out, an increased number of snow-free days, and observed changes in streamflow timing and discharge.
- The majority of the variability in peak and total annual snowpack and streamflow, however, is explained by season-dependent interannual-to-interdecadal changes in atmospheric circulation associated with Pacific Ocean sea surface temperatures.
- Over recent decades, increased spring precipitation appears to be elevating NRM total annual streamflow from what would otherwise be greater snow-related declines in hydrologic yield.

Figure IV-11 Average peak snow-water equivalent (SWE) calculated from 25 stations (black line) in the Northern Rocky Mountains. A regression line (black solid line) shows trends in SWE and is bounded by 95 percent confidence intervals (black dashed lines) with significance (p value) shown (Greg Pederson, written communication 4/1/2014).



Additional work by Pederson and others (2013) examined how unique these recent declines in snowpack are when compared with historical (paleo) periods extending back in time over 1000 years. Using snowpack reconstructions from 66 tree-ring chronologies in key runoff-generating areas of the Rocky Mountains, they found that the late 20th -century snowpack reductions are almost unprecedented in magnitude across the northern Rocky Mountains (Figure IV-11 and IV-12). In addition, these declines occurred over the entire area and resulted from unparalleled springtime warming that is due to positive reinforcement of the anthropogenic warming by decadal variability (Pederson and others, 2013).

Figure IV-12 Changes in the amount of snow accumulation and timing of melt in the western United States over the period 1950-2000.

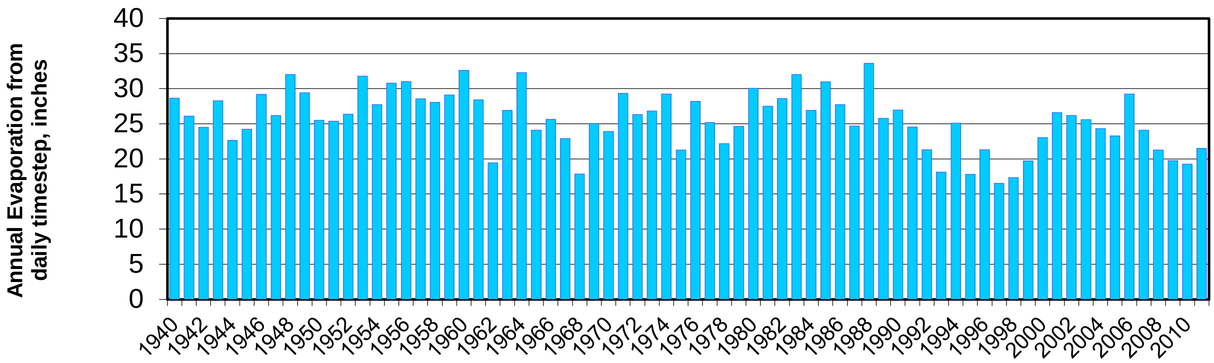


EVAPORATION

Evaporation varies with temperature, which in turn, is strongly affected by elevation. Evaporation in the Yellowstone River Basin is affected more by prevailing wind and sky conditions than by latitude, as shown by published maps of mean annual evaporation for 1956-1970 (Farnsworth and others, 1982). Evaporation is greatest in the windswept basins and prairies, where the mean annual total generally exceeds 35 inches, and surpasses 43 inches in parts of the Bighorn and Powder River Basins and Yellowstone River valley. In the cool, often cloud-shrouded highlands of the Absaroka and Beartooth Mountains, mean annual evaporation is less than 20 inches (Martner, 1986). Evaporation and precipitation together distinguish the moist, mountain forest ecosystem from the lower-elevation regions where evaporation exceeds precipitation (Ostresh and others, 1990; Marston and Anderson, 1991).

Evaporation from open-water surfaces, such as ponds and reservoirs can represent a significant part of the annual water budget. Annual evaporation amounts near Sheridan, Wyoming range from about 16 to 32 inches and average about 27 inches Figure IV-13). For example, the combined net annual evaporation (evaporation minus precipitation on the surface area of the impoundment) from Bighorn Lake (Yellowtail Dam), Boysen Reservoir, Buffalo Bill Reservoir, and Bull Lake Reservoir is approximately 120,000 acre-feet/year (Wyoming State Engineer, 2010).

Figure IV-13 Tongue River Basin near Sheridan Wyoming: estimated annual evaporation amount from open-water surfaces (Allen, R.A. 2012, email communication to Chuck Dalby 12-28-2012).



Drought and Climate Variation

DROUGHT AND EFFECTS OF DROUGHT

Drought is a deficiency of precipitation over an extended period of time, usually several years or more. This deficiency results in a water or soil moisture shortage for some activity, group, or environmental sector. Drought is a normal, recurrent feature of climate, although many erroneously consider it a rare and random event. It occurs in virtually all climatic zones, but its characteristics vary significantly from one region to another. Drought is usually considered relative to some long-term average condition of balance between precipitation and evapotranspiration perceived as “normal”. Drought is related to the timing (i.e., principal season of occurrence, delays in the start of the rainy season, occurrence of rains in relation to principal crop growth stages) and the effectiveness (i.e., rainfall intensity, number of rainfall events) of the rains.

Effects of drought become apparent with a longer duration because more and more moisture-related activities are affected. Agriculturally, non-irrigated croplands are most susceptible to moisture shortages. Rangeland and irrigated agricultural lands do not feel the effects of drought as quickly as the non-irrigated, cultivated acreage, but their yields can also be greatly reduced due to drought. Reductions in yields due to moisture shortages are often aggravated by wind-induced soil erosion.

In periods of severe drought, plant and forest fuel moisture is very low, increasing the potential for devastating wildland and rangeland fires. The most recent extreme fire seasons in 1988, 2000, and 2003 all coincided with sustained drought periods. Under extreme drought conditions, lakes, reservoirs, and rivers can be subject to severe water shortages, affecting irrigation, drinking water, fish populations, and fire suppression water supplies.

In the last 100 years, the first experiences of drought impacts occurred shortly after homesteaders flooded eastern Montana. The homestead boom of 1906 through 1918 “busted” when severe drought swept the state from 1917 through 1923. The drought was compounded by plummeting market prices and banks demanding repayments. The exodus of demoralized homesteaders proved even more rapid than the previous incoming wave of optimistic settlers (Figure IV-14). Of the estimated 100,000 immigrants who flooded into the state (1906-1918), 65,000 departed between the armistice of World War I (1918) and about 1925. The homestead collapse, among other forces, propelled Montana into a depression from which it did not recover until World War II (Montana Historical Society, 2004).

Figure IV-14 July 1936. Miles City Montana. "Drought refugees from Glendive, Montana. Enroute to Washington State" (Photo by Arthur Rothstein for the Resettlement Administration).

Already reeling from the 1919 drought and agricultural disaster, the Dust Bowl years further affected agricultural production and economies throughout the state. The period from 1928 through 1939 is the driest in the historical record. The Palmer Hydrologic Drought Index (PHDI) showed the entire state was in a hydrologic deficit for over 10 years. Other sustained dry periods include the middle 1950s, early 1960s, mid-1970s, and the 1980s (Figure IV-15).

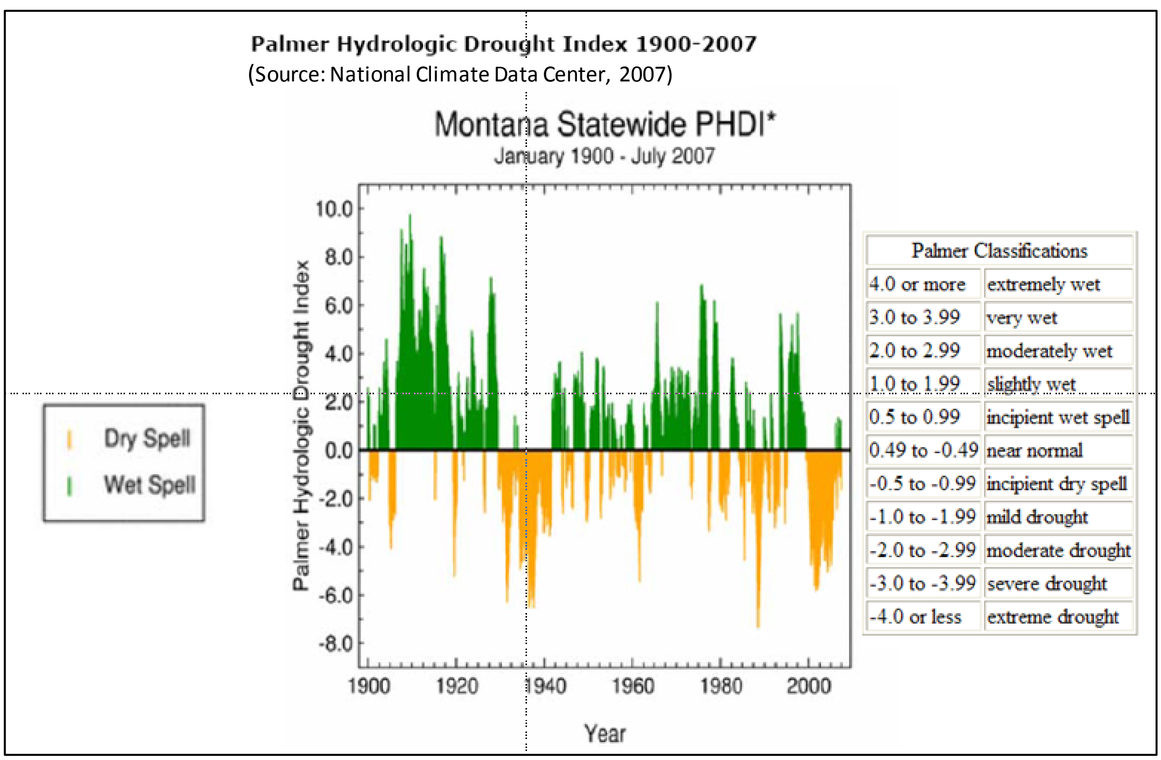


Figure IV-15 The most recent drought from 2000-2007, suggests the dryness and hydrologic deficit mimics the Dust Bowl years.

According to the Palmer Hydrologic Drought Index, Montana has been in severe and extreme drought between 10 and 20 percent of the time in the last 100 years (Figure IV-15).

Extreme high temperature, low humidity, wind, rainfall, and snowpack can all contribute to drought conditions. Montana's weather extremes can be a factor in compounding an existing drought problem. In Glendive on July 20, 1893 and in Medicine Lake on July 5, 1937, the temperature reached 117°F. During 1960, the community of Belfry received only 2.97 inches of precipitation, another Montana extreme. Although Montana is typically known for its extreme winter weather, summertime extremes can also have an impact.

Severe droughts of several-years duration have occurred in the Yellowstone River Basin. Droughts with recurrence intervals greater than 25 years occurred during the periods 1929-1942 and 1948-1962 over most of Wyoming and Montana (Druse, 1991), including nearly all of the Yellowstone River Basin. Such regional drought conditions are common in the upper parts of the Missouri River Basin (Matthai, 1979).

Drought conditions of the 2000s have been compared to the drought of the 1930s during the Great Depression and Dust Bowl period. In Montana, the Dust Bowl period lasted about 11 years, from 1930-1940 (inclusive). Below-normal precipitation was experienced during nearly every year of the Dust Bowl. Additionally, the 1930s were warmer than normal, which, again, exhibits some similarities to conditions of the early 2000s.

HISTORICAL DROUGHTS IN MONTANA

Studies of ancient climate –the paleoclimate— indicate that droughts occurring prior to 1200 A.D. were more frequent and of longer duration than those of the 20th century. Paleoclimate research indicates that regular and persistent droughts existed and were especially pronounced during the years of A.D. 200-370, A.D. 700-850, and A.D. 1000-1200. These drought periods were long and sustained; by comparison, the period from A.D. 1200 to the present is relatively wet (Laird and others, 1996). Examination of more recent paleoclimate, using tree rings to identify dry and wet periods, shows a much wetter period in the United States over the past 300 years. NOAA researchers reconstructed Palmer Drought Severity Indexes from tree-ring data and found that historical droughts, similar in severity and duration to the drought during the 1950s, occurred once or twice a century for the past three centuries in the United States (1860s, 1820s, 1730s). The research also showed that there has not been another drought as extensive and prolonged as the 1930s drought in the past 300 years (NOAA, 2003). Recent studies by climate scientists have extended the historical record of climatic variation in the northern Rocky Mountains (including Montana) to include the past several thousand years; this provides an extended context for understanding natural climatic variation (see Appendix C, Section IV).

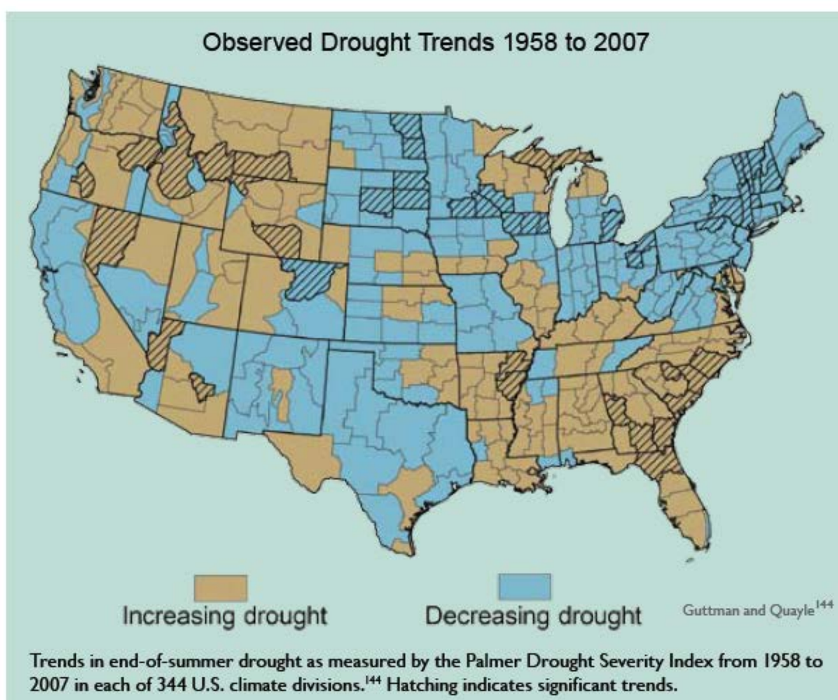


Figure IV-16 Observed Drought Trends in the United States from 1958 to 2007.

EFFECT OF DROUGHTS ON WATER SUPPLY VARIABILITY

In the Yellowstone River Basin, variation in precipitation (especially snowpack) and temperature contribute to fluctuations in streamflow on a daily, monthly and annual basis. The Surface Water Supply Index (based on snowpack, reservoir storage, streamflow and precipitation) describes the degree of drought and availability of water at a point in a watershed (Table IV-2).

Figure IV-17 shows the Surface Water Supply Index (SWSI) for the Yellowstone River above Livingston, and above and below the confluence with the Bighorn River. The pattern of low and high SWSI is remarkably similar across the locations over the 1992-2013 period, with the drought of the 2000s clearly defined, extending from 2000 to 2008. The SWSI does not vary much from the Upper Basin to the Lower Basin which is probably due to the influx of tributary inflow from the Clarks Fork Yellowstone and Bighorn tributaries that significantly replenish flow near the midpoint of the basin.

Table IV-2 Surface Water Supply Index Values

Condition	Amount
Extremely Dry	-4.2 to -3.0
Moderately Dry	-2.9 to -2.0
Slightly Dry	-1.9 to -1.0
Near Average	-0.9 to 1.0
Slightly Wet	1.1 to 2.0
Moderately Wet	2.1 to 3.0
Extremely Wet	3.1 to 4.2

Figure IV-18 shows the historic variation in annual volume of streamflow measured at main stem Yellowstone River Basin stations from 1890-2012; periods of below-average streamflow occurred in 1929-1942, 1950-1960, 1986-1991 and 2000-2007, and generally reflect drought periods in the Yellowstone Basin.

Figure IV- 17 Surface Water Supply Index (SWSI) 1992-2013 for the main stem Yellowstone River locations in the Upper, Middle and Lower Basins.

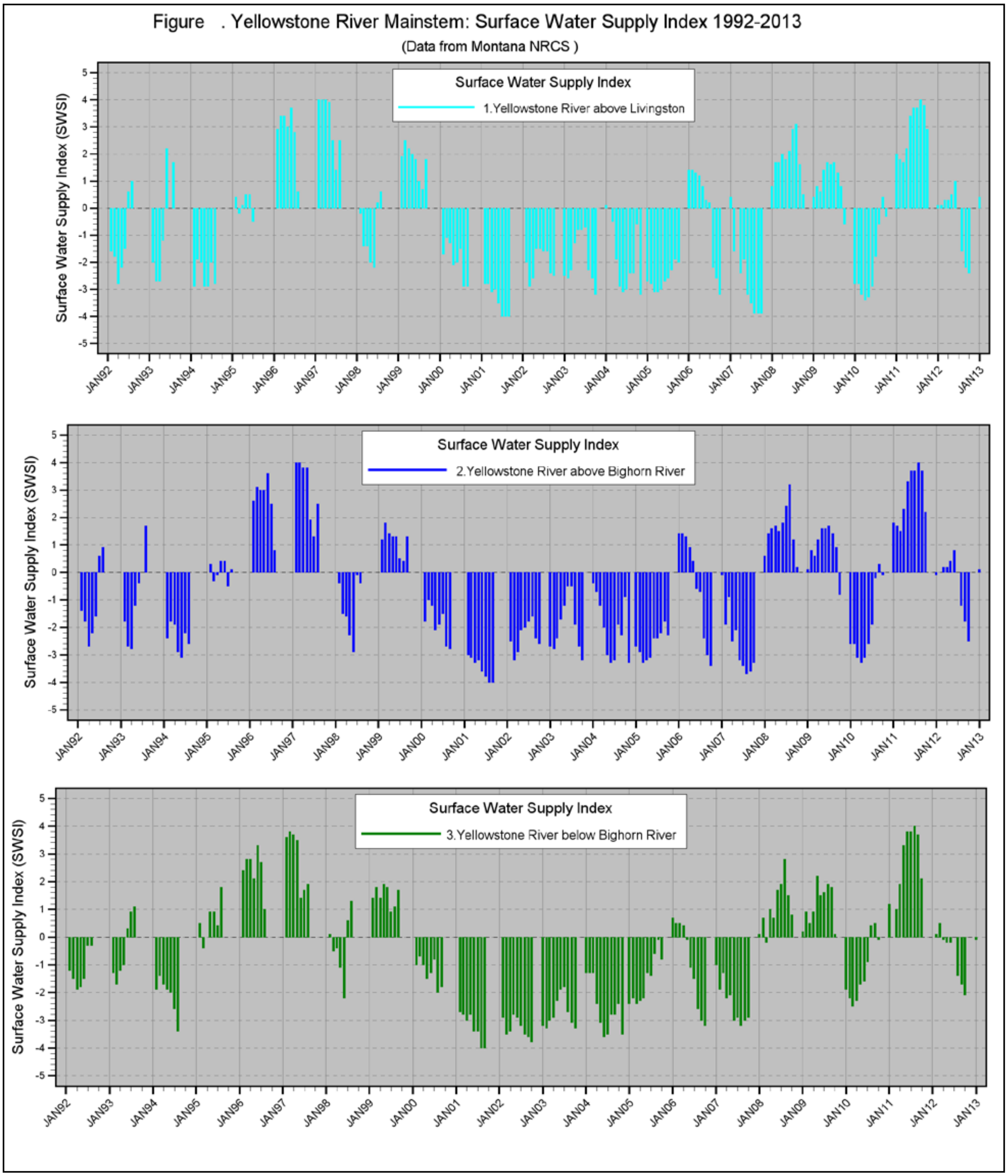
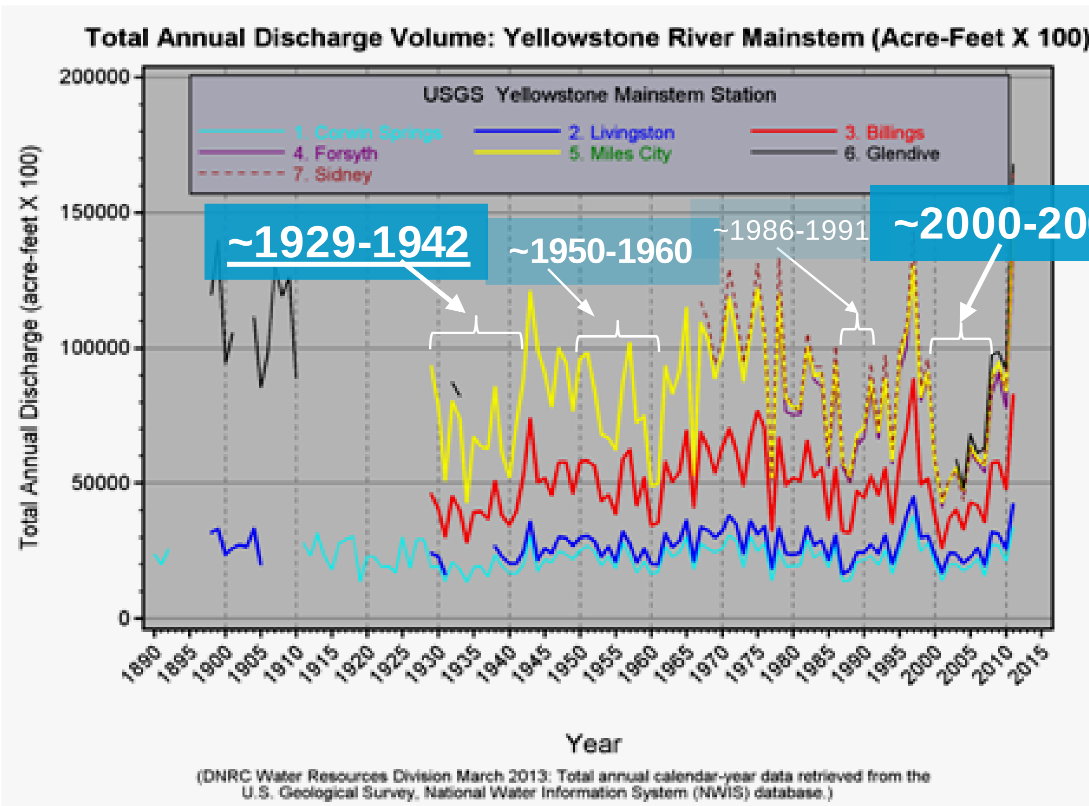


Figure IV-18 Annual volume of streamflow measured at main stem Yellowstone River Basin stations. Periods of below average streamflow include 1929-1942, 1950-1960, 1986-1991 and 2000-2007.



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 Yellowstone River Basin and is correlated to the groundwater system's ability to transmit and store water, location to surface water (recharge), and depth below ground surface. The Montana Bureau of Mines and Geology's Groundwater Information Center 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 or annual trends, while the low-frequency, slowly-varying signals are characteristic of climate sensitive wells (Patton, 2013). The green and red bars on the following groundwater hydrographs represent departures from the mean of the annual precipitation at the closest weather station.

The water levels in the alluvium well near Terry show water level responses to climate variability. Figure IV-19 shows water level changes in the alluvium that are related to dry and wet cycles. The hydrograph shows the impact of annual water level fluctuations superimposed on a low-frequency cycle that is likely climate related.

The water levels in a well completed in the Fort Union Formation near Bloomfield show a response to yearly changes superimposed on a low-frequency cycle. Figure IV-20 shows groundwater levels responding to multi-year trends in climate variability. For example, water levels fell approximately 3 feet during the early 2000s drought period. Water levels rose after 2010 by 10 feet and fell 5 feet a year later.

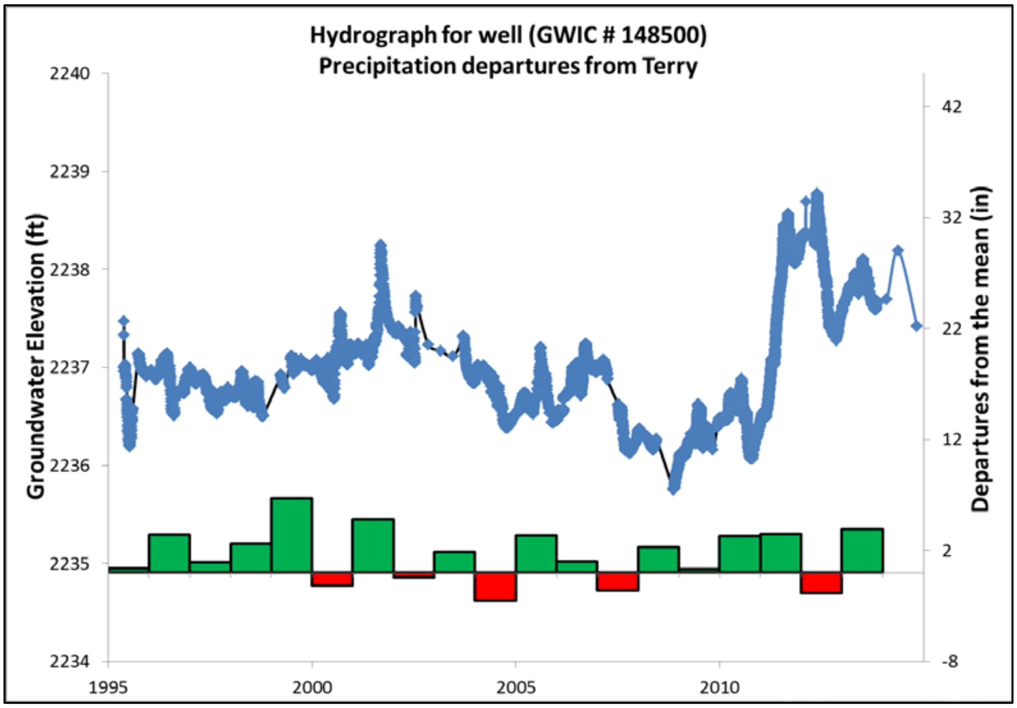


Figure IV-19 Groundwater levels in the alluvial aquifer near Terry showing the effects of drought in the 2000s and recovery during wetter periods (GWIC # 148500).

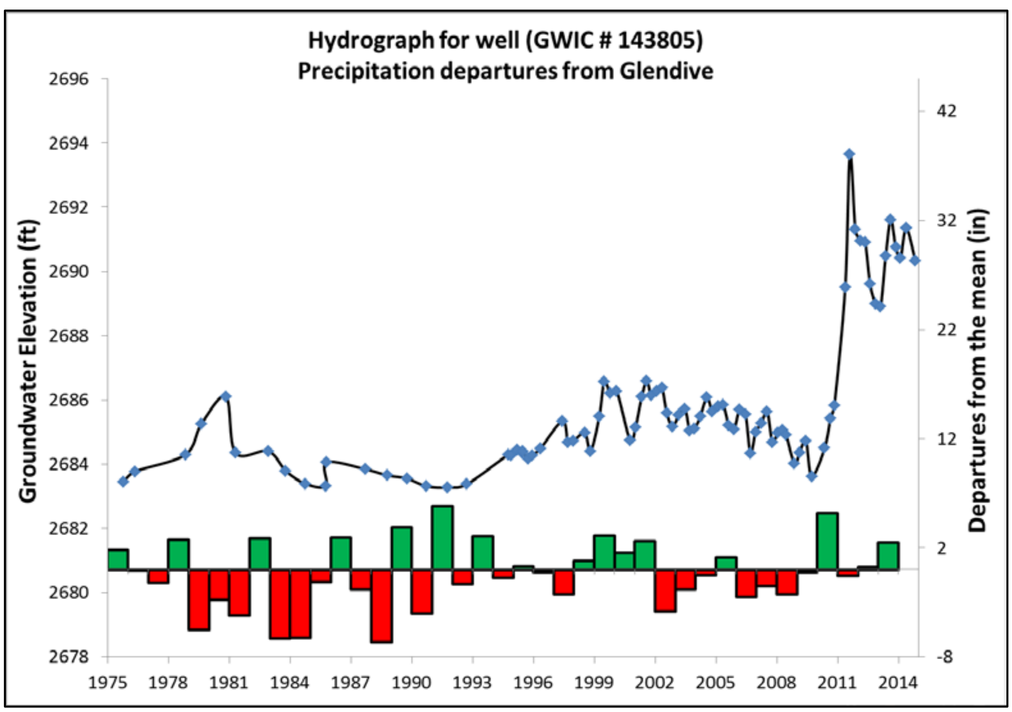
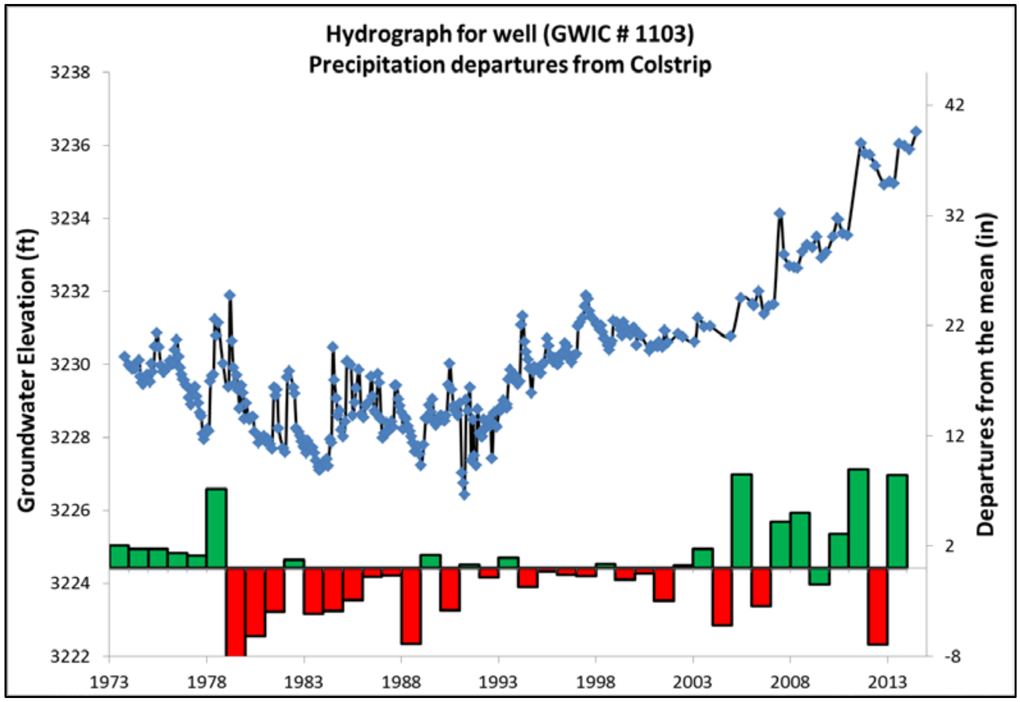


Figure IV- 20 Groundwater levels in the Fort Union Formation Aquifer near Bloomfield showing the effects of drought in the 2000s and recovery during wetter periods (GWIC # 143805).

Figure IV-21
Groundwater levels in the Fort Union Formation Aquifer near Colstrip showing responses to above average years of precipitation and long-term cyclic upward trends (GWIC # 1103).

A monitoring well in the Fort Union Formation near Colstrip shows annual changes and multi-year trends related to climate variability. Figure IV-21 shows a declining cyclic trend with water levels falling approximately 3 feet prior to 1990. Since 1990, water levels have risen 8 feet.



EFFECTS OF CHANGES IN TIMING AND LOCATION OF PRECIPITATION AND SNOWPACK RUNOFF

Seasonal variations in temperature and precipitation produces fluctuations in streamflow over a single year and affects the timing and amount of water measured at a location. Recent studies show that as the temperature has warmed, the snowpack tends to melt earlier. For example in 2007, the last day with snow accumulation arrived four to eight weeks earlier than the long-term normal (Figure IV-22).

Figure IV-22 Upper elevation snow courses in Bighorn Mountains showing complete melt of snowpack in 2007 that is four to eight weeks earlier than the long-term normal date.

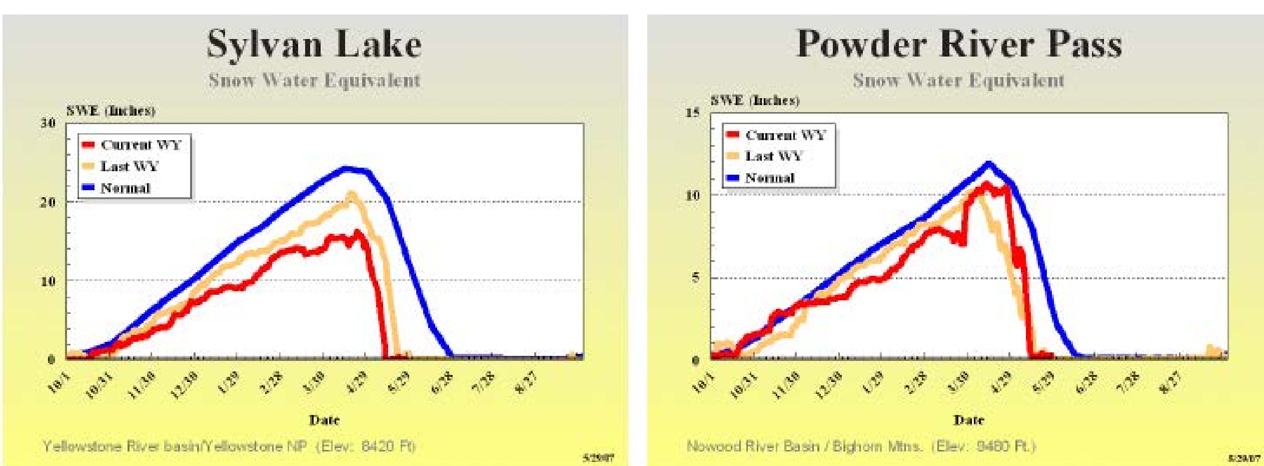
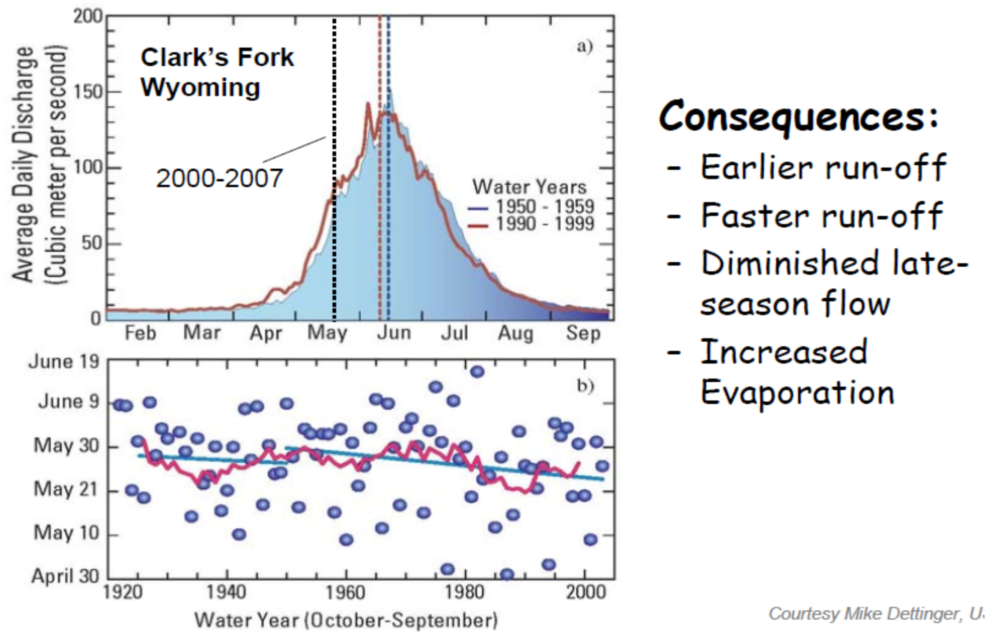


Figure IV-23 Comparison of annual hydrographs showing similarity between 1950-1959 and 1990-1999 periods and advance in date of peak runoff for 2000-2007; (bottom) trend toward earlier peak runoff over 1920 to 2007 period (Dettinger, 2005).



In addition, the average annual hydrograph for the Clarks Fork Yellowstone shows (Figure IV-23) a shift toward an earlier runoff peak—with the peaks for the 2000-2007 being almost a month earlier than occurring in the period 1950-1999

Surface Water Resources of the Yellowstone River Basin

STREAMFLOW

Most of the annual streamflow from the Yellowstone River Basin originates in the mountainous areas of the upper Yellowstone River and the Clarks Fork Yellowstone River and Wind/Bighorn River Basins. Representing about half of the Yellowstone River Basin's total drainage area, the combined mean annual flows from the upper Yellowstone, Clarks Fork Yellowstone, and Wind/Bighorn Rivers equal about 90 percent of the mean annual flow measured near the mouth of the basin at Sidney, Montana (Figure IV-5). Runoff amounts from the basins and plains areas are lower than those from the mountainous areas. Unit annual runoff in the Yellowstone River Basin ranges from 1.3 cfs/mi^2 in the mountainous headwaters to 0.003 cfs/ mi^2 in the lower-elevation, semi-arid, plains (See Appendix D, Section IV, Table 3).

Streams in the mountainous areas of the Yellowstone River Basin generally are perennial (Wahl, 1970; Lowham, 1988). Most of the flow in mountain streams is from snowmelt runoff. Annual streamflow in the mountainous areas are dominated by a single snowmelt peak of moderate duration during late spring/early summer with low variability in daily mean discharge throughout the year, and a smaller early spring peak (Figures IV-25—IV-28). Variability in annual flows in streams in the mountainous areas of the basin is generally small—relative to the intense localized convective rainstorms of the basins and plains areas—and mountain snow accumulations are less variable in aerial extent and between years.

Most streams originating in the basins or plains areas of the Yellowstone River Basin are ephemeral, flowing only as a result of local snowmelt or intense rainstorms (Wahl, 1970; Omang, 1992). Intense localized convective rainstorms can produce most of the total flow for any given year in these watersheds. The distribution and occurrence of these events vary between years (Lowham, 1988). Because of the localized extent and annual variability of these storms, the resulting flows in any given watershed are variable between years. Annual flow of streams originating in the basin or plains areas often consist of multiple peaks: a lowland snowmelt peak of moderate duration occurring late winter/early spring and several rainstorm peaks of short duration occurring late spring through late summer (Figures IV-25—IV-28).

Streamflow characteristics in the Yellowstone River Basin vary by geographic location, time of year, and degree of human influence. For most streams in the basin with little or no flow modifications, streamflow characteristics can be described by annual streamflow and flow duration at representative locations. For streams where human activities have modified the natural drainage, regulation, diversion, and return flows affect streamflow characteristics to varying degrees. Variations in geography and weather cause severe floods and droughts in the basin. The typical annual hydrograph for the Yellowstone River downstream from Billings (Figure IV-26) consists of a lowland snowmelt peak during the late winter/early spring followed by a peak from the mountain snowmelt during the late spring/early summer (Zelt and others, 1999). Several short-to moderate-duration rainstorm peaks usually augment the spring/summer snowmelt peaks and the summer base flows.

Figure IV-24 Little Bighorn River.

The period of observation for mean annual discharge in the Yellowstone basin varies significantly, with main stem gages in Montana having nearly continuous records since the 1930's. Smaller tributaries tend to have shorter periods of observation and measurements emphasizing recent streamflow. Mean annual discharge for stations with at least 30 years of record was compared with the mean computed for several shorter periods of

interest that represent dry conditions: 1929-1941, and 2000-2010 (Table IV-3), and with the period currently used as the base for reporting hydrologic observations—1981 to 2010. In general, mean annual discharge was less than the long-term mean for most stations for all three periods. The dry periods from 1929-1941 and 2000-2010 show similar reductions in streamflow, compared with the long-term value (see Appendix D, Section IV, Table 3).

Eleven stations have complete periods of record from 1929-2010 (Table IV-3). For main stem stations, the mean difference between the period of record mean and the 1981-2010 mean, is -3.4 percent; for 1929-1941 the difference is -17.5 percent; and for the 2000-2010 the difference is -14.2 percent. For tributary stations, the mean difference between the period of record mean and the 1981-2010 mean, is -11.7 percent; for 1929-1941 the difference is -6.0 percent; and for the 2000-2010 the difference is -26.6 percent. Streamflow over the 1981-2010 period was about -3.4 percent (main stem) to -11.7 percent (tributaries) less than the long-term 1929-2010 mean. The period 1929-1941 produced the least streamflow for main stem stations (-17.5 percent compared with period of record), but tributaries were less affected (-6.0 percent compared with period of record). The period 2000-2010 appears to deviate the greatest from the long-term mean for both the main stem (-14.2 percent) and tributary stations (26.2 percent).

Table IV-3 Percent difference in mean annual discharge compared with long-term mean for tributary and mainstem stations with full period of record 1930-2010.

	USGS Station	Drainage Area	Period of Measurement	Number of Years	Percent Difference 1981-2010 Mean From Period of Record Mean	Percent Difference 1929-1941 Mean From Period of Record Mean	Percent Difference 2000-2010 Mean From Period of Record Mean
Yellowstone River at Yellowstone Lake Outlet, Yellowstone National Park, Wyoming	06186500	991	1922-82, 1983-86, 1988-2013	81	-1.1	-17.3	-9.8
Yellowstone River at Corwin Springs, Mont.	06191500	2,619	1889-93, 1910-2013	105	-1.0	-16.5	-9.3
Yellowstone River near Livingston, Mont.	06192500	3,551	1897-1905, 1928-32, 1937-2013	86	-2.7	-15.9	-10.7
Yellowstone River at Billings, Mont.	06214500	11,805	1904-05, 1928-2013	84	-5.2	-21.1	-19.6
Yellowstone River at Miles City, Mont.	06309000	48,253	1922-23, 1928-2013	70	-6.9	-16.4	-21.6
				Mean=	-3.4	-17.5	-14.2
Clarks Fork Yellowstone near Belfry, MT	06207500	1,154	1921-2013	91	-5.9	-14.8	-11.4
Bighorn River at Kane WY	06279500	15,762	1929-2013	83	-18.5	-3.2	-47.0
Tongue River near Dayton WY	06298000	206	1919-1926, 1941-2013	81	-9.6		-18.1
Tongue River at Dam, near Decker MT	06307500	1,770	1939-2013	74	-11.1		-22.7
Powder River at Moorehead MT	06324500	8,086	1929-2013	81	-8.1	-3.9	-25.7
Powder River near Locate, Mont.	06326500	13,068	1938-2013	75	-16.8	-2.1	-34.6
				Mean=	-11.7	-6.0	-26.6

Figure IV-25 Yellowstone River at Livingston Montana Mean Daily discharge of minimum, average and maximum years (Based on annual volume of flow 1930 to 2011).

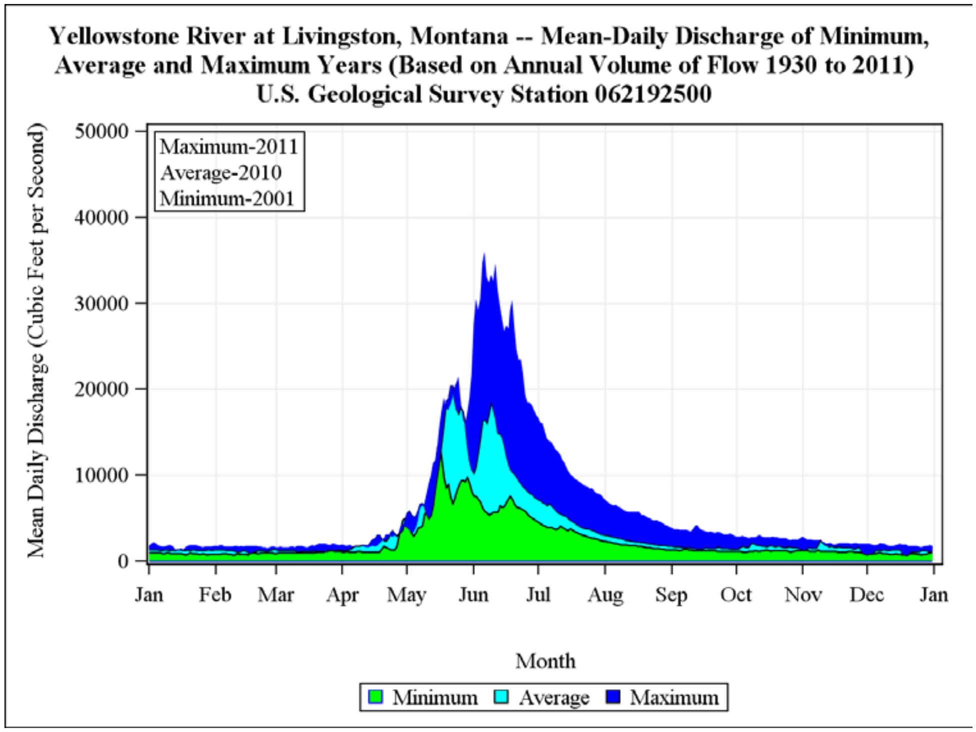


Figure IV-26 Yellowstone River at Billings Montana Mean Daily discharge of minimum, average and maximum years (Based on annual volume of flow 1930 to 2011).

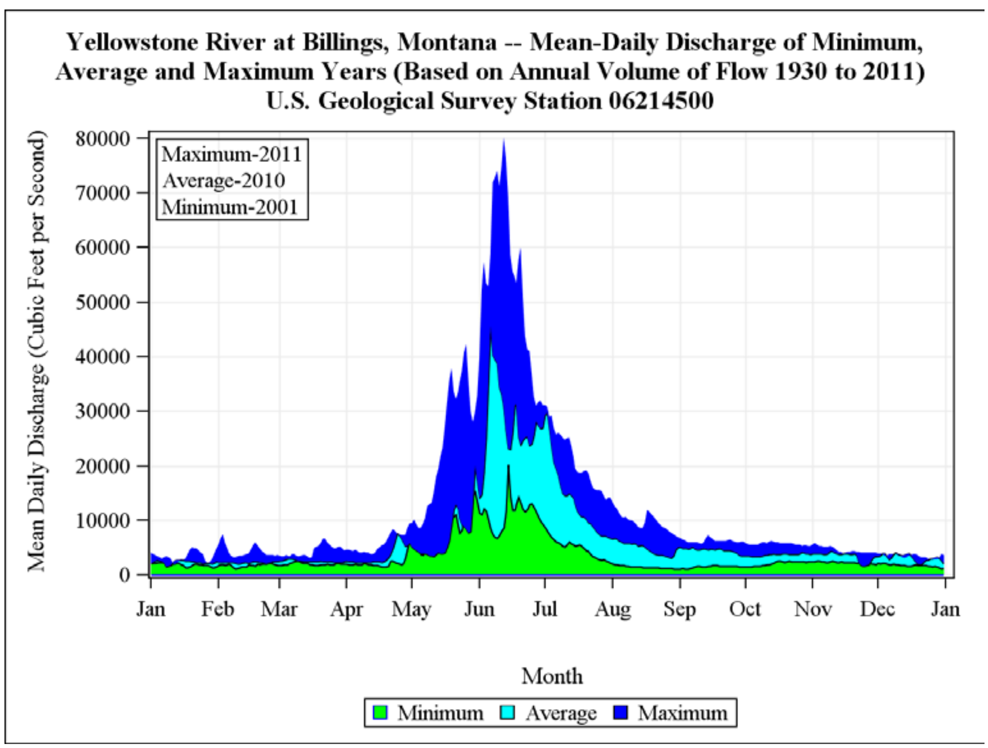


Figure IV-27 Yellowstone River at Miles City Montana Mean Daily discharge of minimum, average and maximum years (Based on annual volume of flow 1930 to 2011).

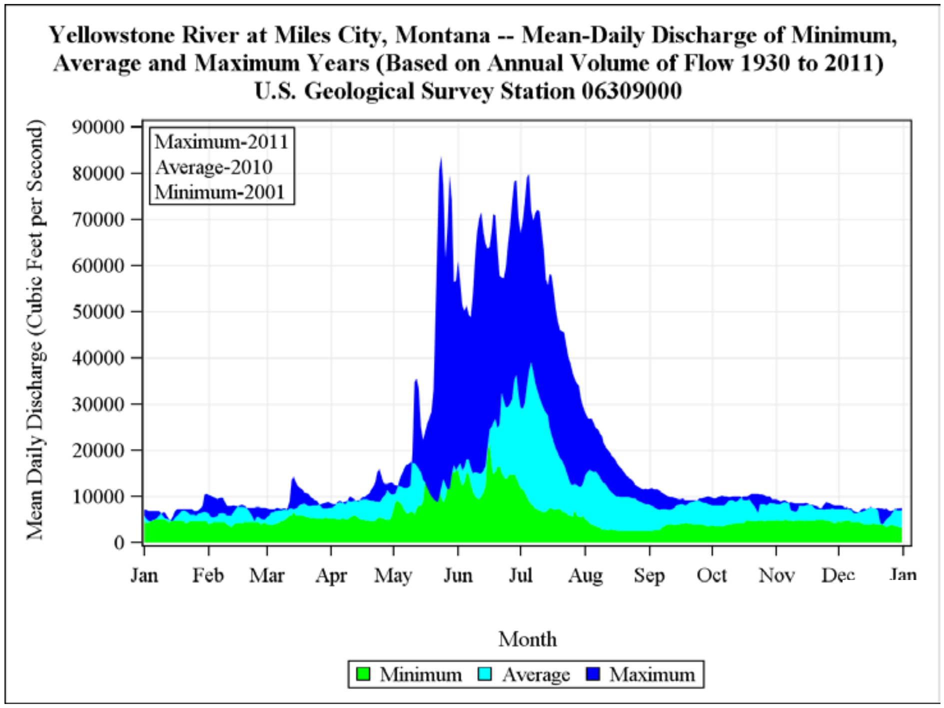


Figure IV-28 Yellowstone River at Sidney Montana Mean Daily discharge of minimum, average and maximum years (Based on annual volume of flow 1930 to 2011).

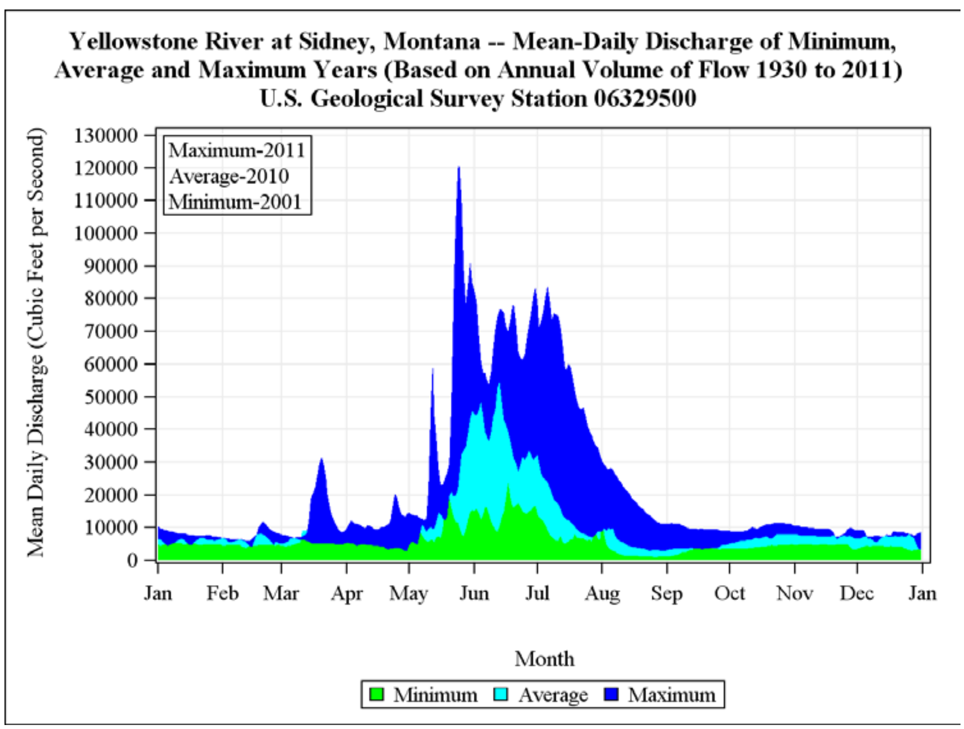


Figure IV-29 Annual departure from mean annual streamflow at Billings and Sidney Montana showing the drought of the 1930's and early 2000's.

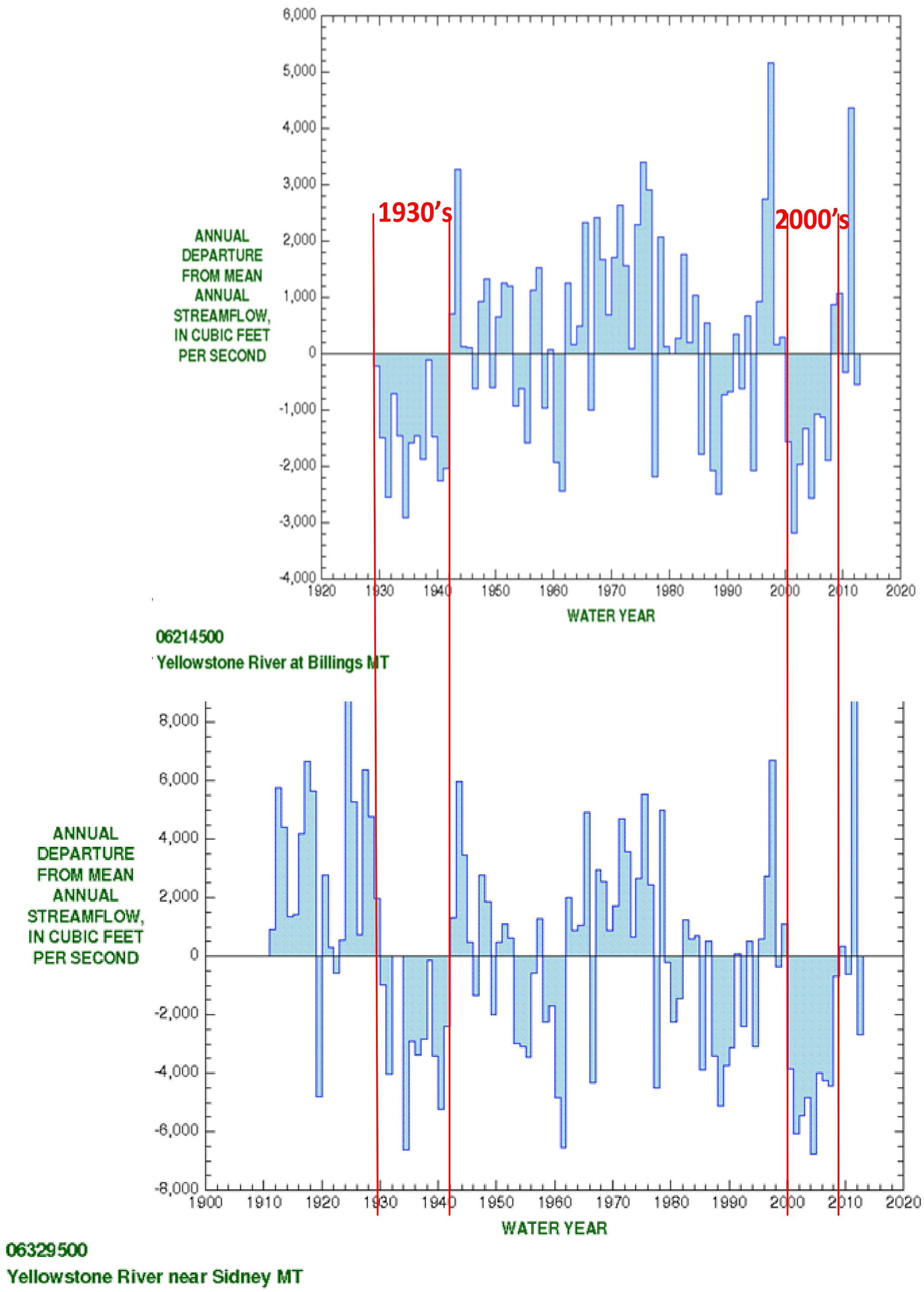
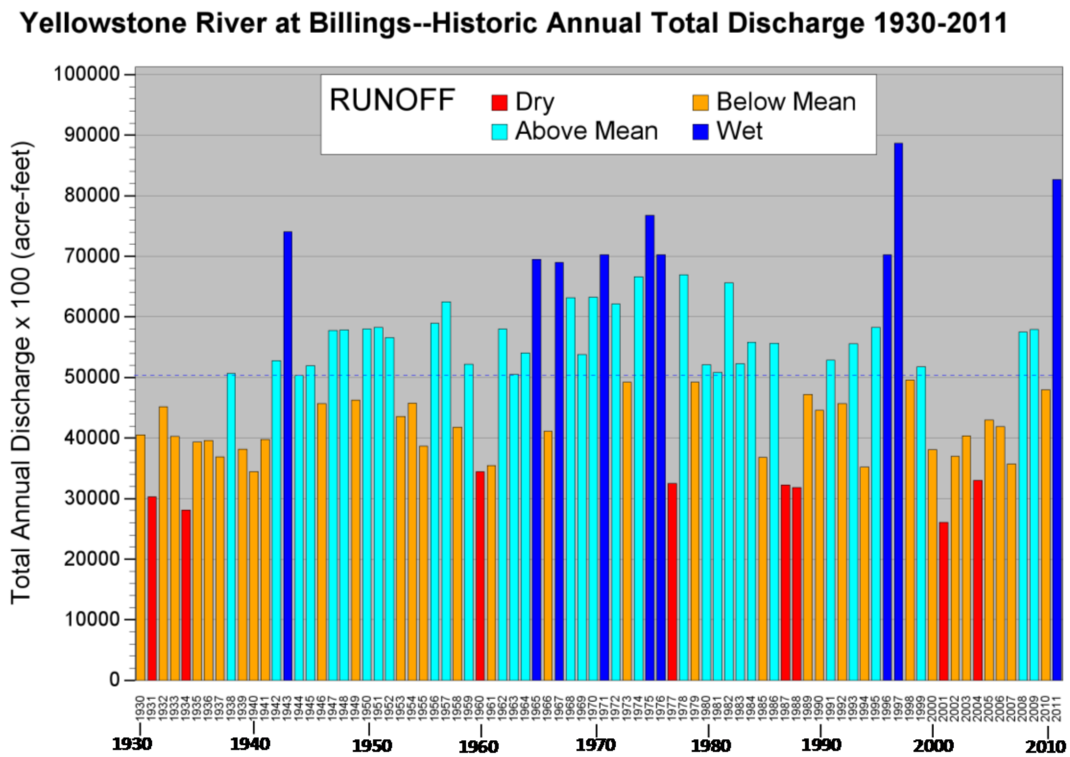
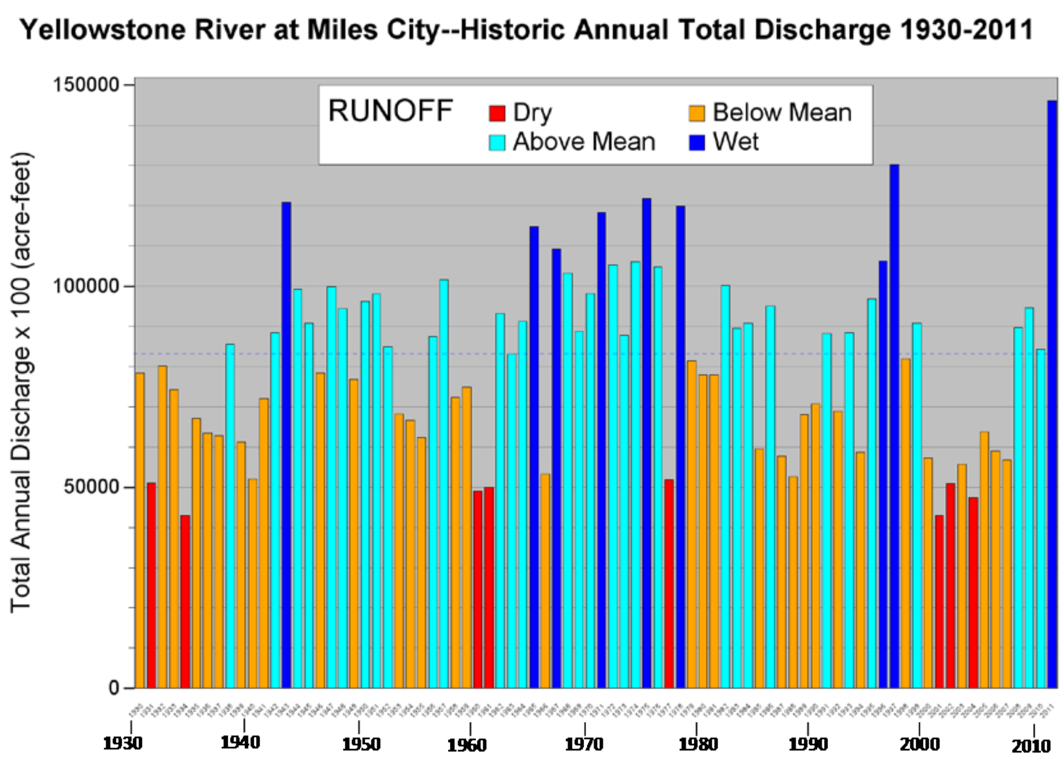


Figure IV-30 Comparison of annual total streamflow at Billings and Miles City Montana.





FLOODS

Flooding in the Yellowstone River Basin can occur as a result of snowmelt, widespread rainfall, or intense thunderstorms. In mountainous areas of the basin, most flooding occurs during spring and early summer from rapid snowmelt. Flooding in the basins and plains occurs during winter and early spring from lowland snowmelt, during spring from large regional rainstorms, and during summer and fall from intense localized thunderstorms. High antecedent soil moisture, frozen ground, and rainfall on melting snowpacks contribute to the most severe floods (Holnbeck and Parrett, 1996).

Figure IV- 31 Upper Yellowstone River near Pine Creek at flood stage.

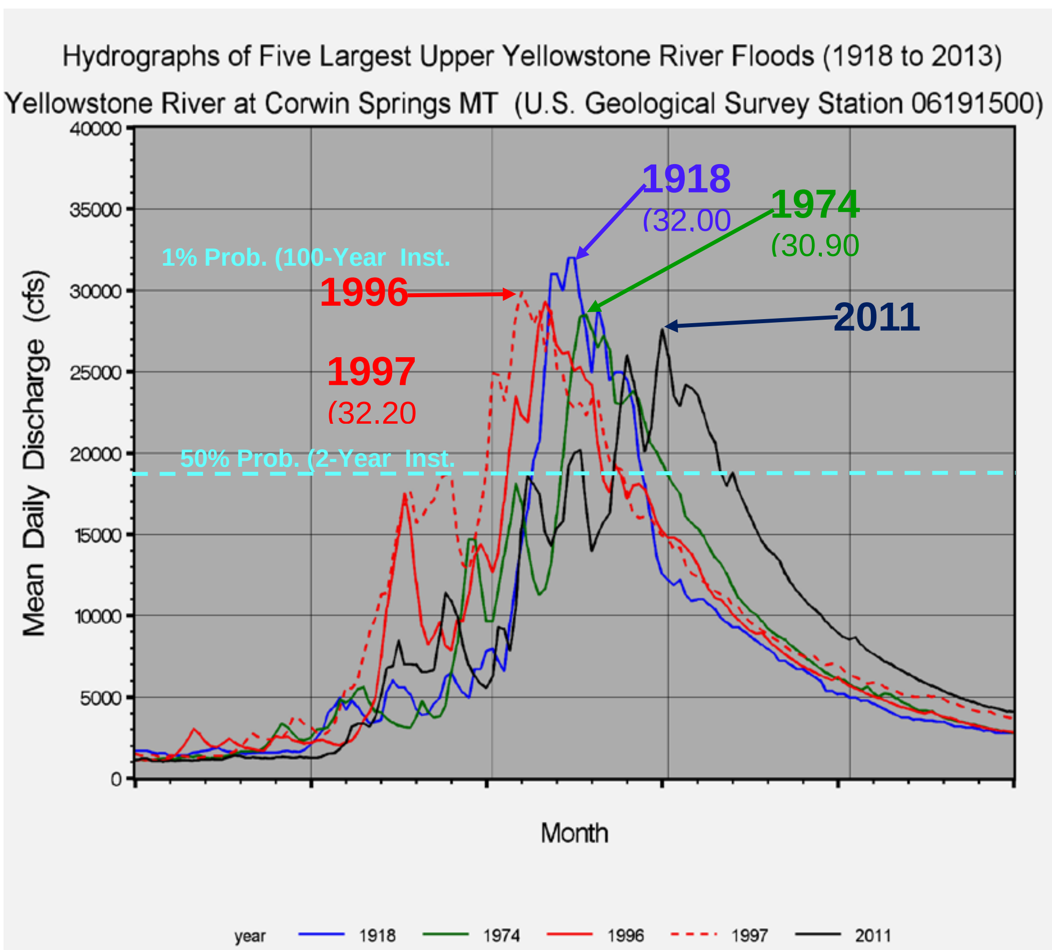
Flooding occurred during 1923 in parts of the Yellowstone River Basin during July 23-25 and again during September 27-30 as a result of widespread thunderstorms and rainfall. Referred to by long-term residents as "the big floods of 1923," these were the most severe floods since 1880 and were during the period 1918-1927 in which more large floods occurred in Wyoming than any other decade (Cooley, 1990). Peak flow recurrence intervals exceeded 100 years at several USGS stations in the Wind, Bighorn, and Powder River Basins (Druse, 1991). The 1923 peak discharge for the Powder River at Arvada, Wyoming of 99,940 cfs (Smalley and others, 1997) is twice the next largest peak of record (period of record 1919-96). The flood of 1943 (Figure IV-30) is important because it provided significant motivation for Congress to pass the 1944 Flood Control Act.

Severe flooding occurred during May 1978 in southeastern and south-central Montana and northeastern Wyoming (Merritt and others, 1991). Watersheds affected in the basin included the Yellowstone River from near Billings to Miles City, Montana; the Bighorn, Tongue, and Powder Rivers; and many smaller tributary watersheds (Parrett and others, 1984). Widespread rain on saturated soils combined with bankfull snowmelt runoff conditions in most streams. Flood recurrence intervals exceeded 50 years for most of the affected area (Merritt and others, 1991). Sediment transport is often very high during floods. Record maximum daily suspended-sediment loads at four sites were measured on the Powder River. Other major floods occurred in the Yellowstone River Basin during 1918, 1943, 1962, 1963, and 1981 (Druse, 1991; Merritt and others, 1991).

More recent floods in 1996 and 1997 caused widespread channel damage in some segments of the Yellowstone Basin—especially in the Paradise Valley upstream from Livingston (Figures IV- 31 and 32).

(Note that the peak instantaneous discharges were larger than the mean daily values shown in the figure.)

Figure IV-32 Hydrographs of the five largest floods (1918 to 2013) measured at Corwin Springs Montana.

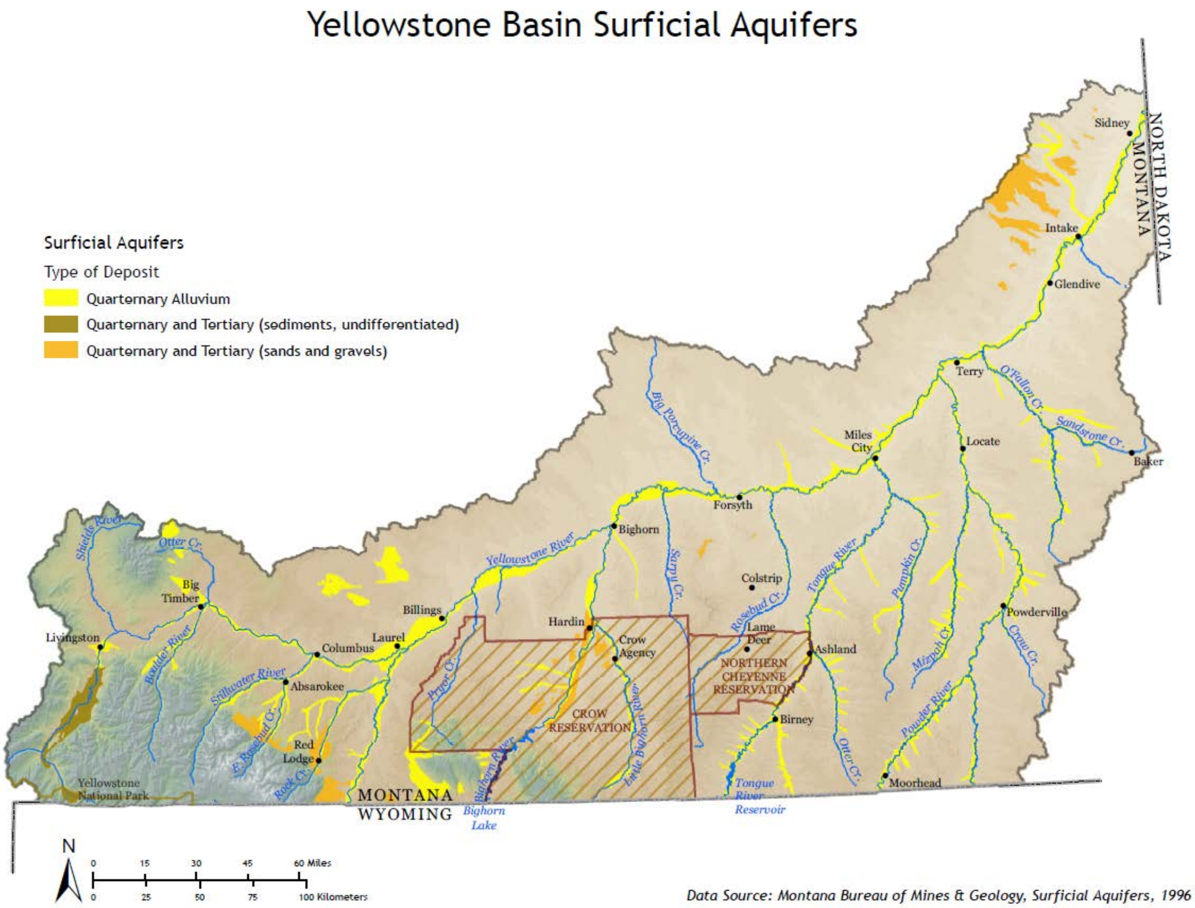


Groundwater Resources of the Yellowstone Basin

SHALLOW ALLUVIAL AQUIFERS

The most commonly used sources of groundwater in the Yellowstone River Basin are found in shallow sand and gravel aquifers in unconsolidated material along floodplains of all the major streams and rivers (Figure IV-33). Shallow alluvial aquifers are generally less than 150 feet thick and, therefore, are accessible by shallow wells at relatively low expense. The shallow aquifer systems of the Bighorn River, Tongue River, Powder River, and Upper, Middle, and Lower Yellowstone River sub-basins are described below.

Figure IV-33 Yellowstone Basin Shallow Aquifers.



The alluvial aquifers of the Bighorn River sub-basin are composed of approximately 30 feet of sand and gravel beds that may yield as much as 100 gallons per minute (gpm). The terrace deposits of older alluvium are permeable, but their saturation thickness varies and may yield up to 30 gpm. The alluvial fan, colluvial, and eolian deposits yield small volumes of water (Hamilton and Paulson, 1968).

The alluvial aquifers of the Tongue River sub-basin are composed of sand and gravel beds (clinker fragments) that yield adequate water for domestic and stock supplies. This alluvium underlies the floodplains and yields as much as 700 gpm and an average of approximately 50 gpm. The surficial deposits on the upland areas of the Tongue River sub-basin yield insufficient water for most uses (Hopkins, 1973).

The Powder River sub-basin alluvium consists of unconsolidated silt, sand, and gravel and occurs along rivers and major drainages (USGS, 1973). The Powder River alluvium ranges from 4 feet to 45 feet thick, but commonly is 10 to 30 feet thick and about 0.5 mile wide (Ringen and Daddow, 1990).

In the Paradise valley of the upper Yellowstone River sub-basin, the alluvial aquifers are composed of well-sorted sand and gravels of the Paradise valley glacial outwash deposits. These glacial outwash deposits are up to 1,000 feet thick and have extensive clay deposits up to 100 feet thick (Lopez and Reiten, 2003). These clay deposits create semi- to leaky-confined aquifer systems in the valley. Groundwater in the alluvium/outwash aquifer fluctuates from 1 foot to 20 feet throughout the year (MBMG, 2005).

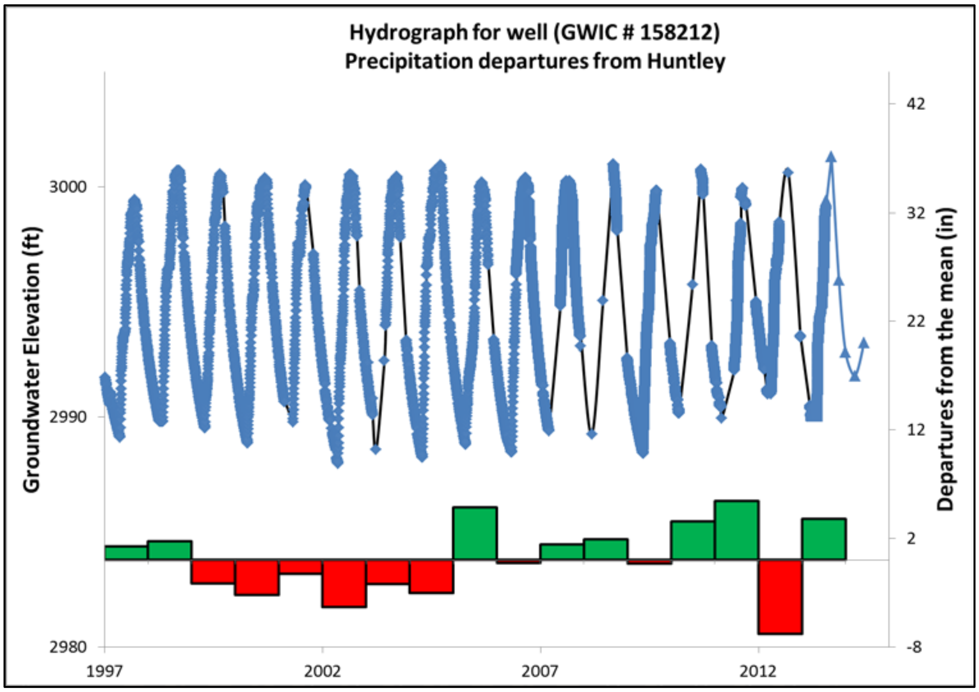
The alluvial aquifers of the middle Yellowstone River sub-basin are composed of a mix of interbedded sand, gravel, silt, and clay. Where saturated, these alluvial deposits form productive aquifers. Two-thirds of all the wells are completed in alluvial aquifers and their distribution corresponds to both the deposit's aerial extent and the population density. Groundwater from the alluvial aquifers is mostly produced from within 30 feet of the land surface and is a preferred water source because it is shallow and productive. The reported well yields range between 10 gpm and 85 gpm, with a median of 30 gpm (Madison et al., 2014).

The Lower Yellowstone River sub-basin alluvial terrace deposits vary in thickness and are laterally and vertical discontinuous; however there is sufficient hydraulic continuity and it is considered a single groundwater flow system (Patton et al., 1998). Reported well yields average approximately 35 gpm in the alluvial terrace deposits. Records in the MBMG's Groundwater Information Center (GWIC) database show that almost 70 percent of total wells obtain water from the alluvial terrace deposits, making it the most utilized groundwater source in the Lower Yellowstone River sub-basin. The alluvial terrace deposits are used primarily for domestic potable water, and to a lesser degree for industrial, irrigation, and stock water. The underlying rock type in the Lower Yellowstone River sub-basin is usually shale, making the alluvium and the alluvial terrace deposits the sole source for groundwater (Olson, 2005).

The Lower Yellowstone Buried Channel aquifer thickness is between 100 feet and 250 feet, with the deeper sand and gravel deposits being the most productive. The buried channel aquifer is an abandoned ancestral channel of the Yellowstone that is approximately 2,500 feet wide and is incised into, and bounded by, the Fort Union Formation. Reported well yields range between 500 gpm to 1,500 gpm in the sand and gravel deposits when their saturated thickness is greater than 20 feet. This aquifer is used primarily for irrigation and domestic potable water (Reiten, 2008).

Recharge to the shallow aquifer systems is primarily derived from seepage from the streams and rivers, stored during periods of higher streamflow, and discharged back to the stream or river during low flows. Other recharge sources include infiltration of precipitation, irrigation water lost by percolation through fields, and leakage from ditches. Additional recharge is provided by underlying strata and coal seams that either outcrop along canyon walls, forming springs, or intersect and discharge into alluvium under the rivers. Water also discharges from the aquifer in the form of springs and seeps along the valley bottom of the Yellowstone River and its tributaries. Figure IV-34 shows the seasonal recharge and trends in precipitation and runoff that are typical of shallow aquifer systems. Another trend in shallow wells is of increasing water levels during irrigation season from irrigation or canal leakage. The green and red bars on the following groundwater hydrographs represent departures from the mean of the annual precipitation at the closest weather station.

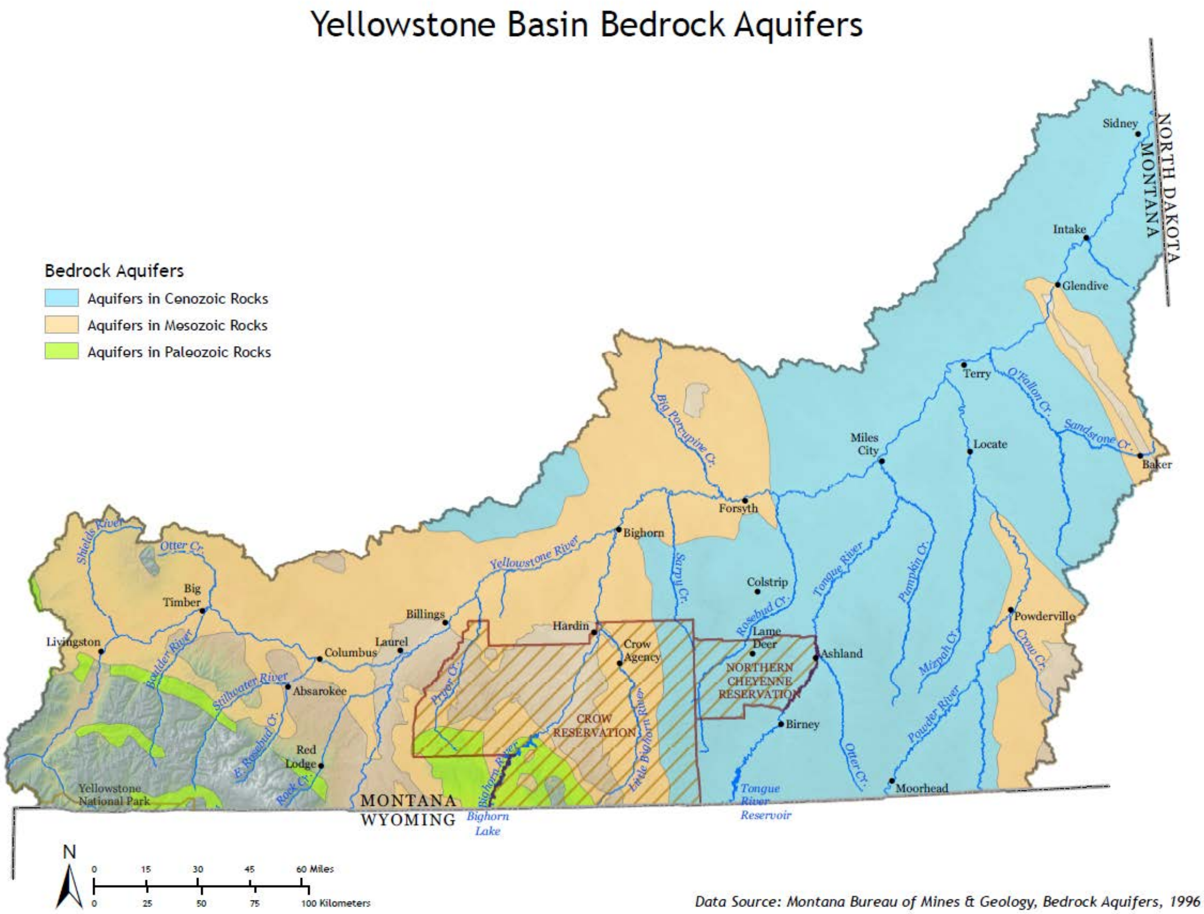
Figure IV-34 Water level in a well (GWIC # 158212) completed in the Yellowstone River alluvium near Huntley.



SANDSTONE AQUIFERS

The bedrock aquifers are found in sandstone, siltstone, shale, and carbonate rock types of the Cenozoic, Mesozoic, and Paleozoic eras (Figure IV-35). The major sedimentary rock aquifers consist of multiple sandstone units separated by thick sequences of shale. Sandstone of the Tongue River Member of the Tertiary Fort Union Formation is the shallowest and the most utilized sandstone source of groundwater (MBMG, 1978; Slagle, 1983). The Tullock Member of the Fort Union Formation is semi-productive in the Lower Yellowstone River sub-basin. Most of the water from this aquifer system discharges to springs and streams along the Yellowstone River Valley, but part of the water continues downward to the underlying Hell Creek and Fox Hills Aquifers (Slagle, et al., 1983). The Lebo Shale of the Fort Union Formation and Bearpaw Shale are considered regional confining units.

Figure IV-35 Yellowstone Basin Bedrock Aquifers.



Another important sandstone aquifer is the lower portion of the Cretaceous Hell Creek Formation and the entire Cretaceous Fox Hills Formation. This is a regional aquifer and occurs at depths from 600 feet to 1,600 feet below the land surface throughout most of the Lower Yellowstone River sub-basin (Smith et al., 2000). Flowing Fox Hills–lower Hell Creek Aquifer wells are usually found in the valley bottoms of large streams and rivers and have potentiometric surfaces that are 50 feet to 100 feet above the land surface. Figure IV-36 shows a water level decline of approximately 1 foot per year. Declines of 1 to 3 feet a year are observed in monitoring wells throughout the Yellowstone River Basin (Reiten, 2013). Stable groundwater level trends exist in Fox Hills–lower Hell Creek monitoring wells in areas where the Fox Hills crops out at the land surface and near Fort Peck Reservoir.

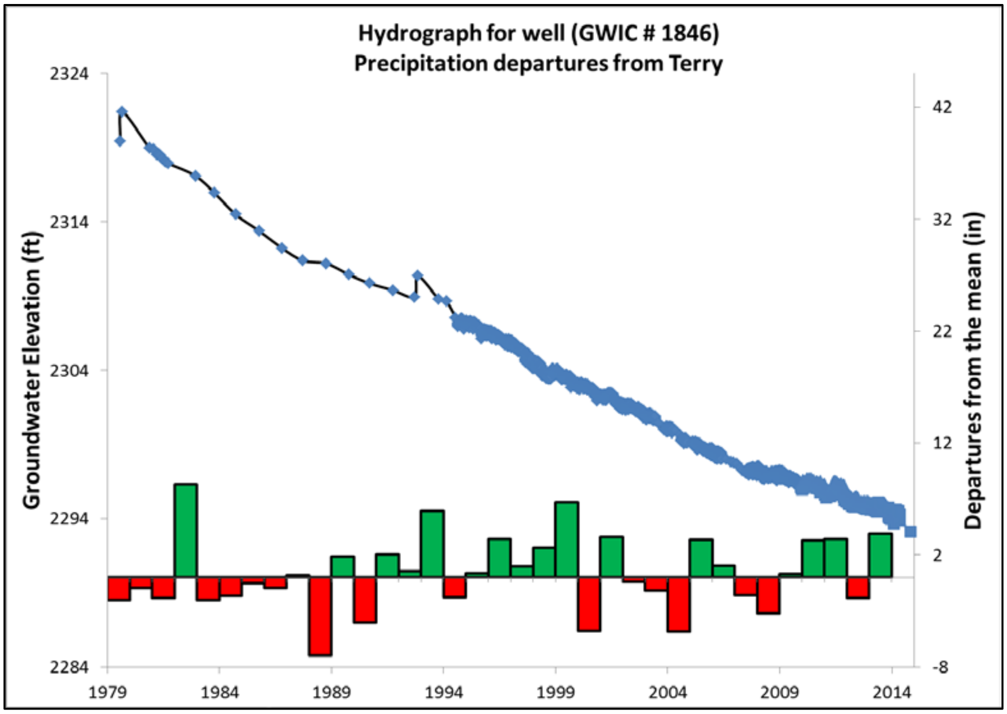


Figure IV-36 Water level in a well (GWIC # 1846) completed in the Fox Hills–lower Hell Creek Aquifer near Terry that has a water level decline during the period of record.

The Judith River Formation is 400 feet thick in the lower Yellowstone River sub-basin (Lopez, 2000). Water quality in most of the Judith River Aquifer in the lower Yellowstone River sub-basin is highly mineralized and marginal for many uses. Where water quality is suitable, the Judith River Aquifer is a source for domestic and stock water, with well yields between 5 gpm and 15 gpm in the lower Yellowstone sub-basin (Olson and Svingen, 2006). In the middle Yellowstone sub-basin, the most suitable water quality is found where the Judith River Formation outcrops or is overlain by alluvium. Well yields in the middle Yellowstone sub-basin are between 7 gpm and 20 gpm, with a median of 10 gpm (Madison et al., 2014). Figure IV-37 shows the seasonal variation in groundwater trends in a shallow aquifer system of the Judith River Formation. The early 2000s drought had a noticeable effect on the groundwater trend, as do wet periods later in the decade.

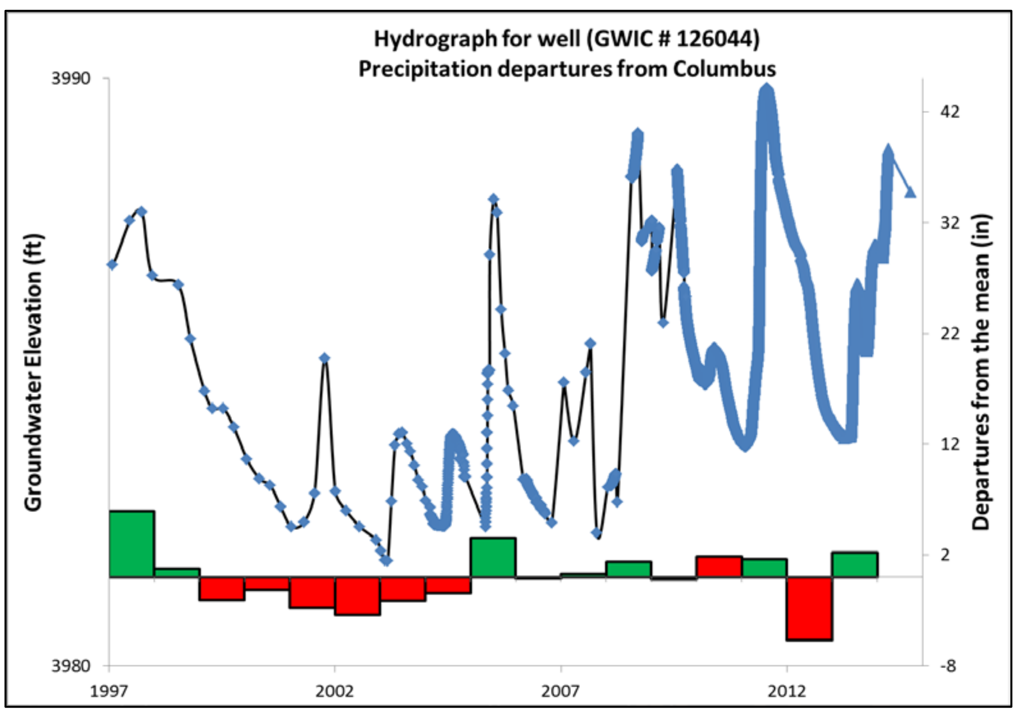


Figure IV-37 Water level in a well (GWIC # 126044) completed in the Judith River Aquifer near Columbus.

In central Montana, the Eagle Formation outcrops at Bull Mountains and Cat Creek anticline. Flowing Eagle Aquifer wells are common at these outcrop locations (Reiten and Hanson, 2008). The Eagle Aquifer is a source for domestic and stock water, with well yields between 5 gpm and 16 gpm and a median of 10 gpm (Olson and Reiten, 2003; Madison et al., 2014). Where the Eagle Formation dips into the subsurface and is overlain by the Claggett Shale, the aquifer contains highly mineralized water that is not suitable for most uses.

Recharge to sandstone aquifers is primarily derived from seepage from streams and rivers, infiltration of precipitation, snowmelt in topographically high outcrop areas, and leakage through confining units. Other recharge sources include irrigation water lost by percolation through fields and leakage from ditches. On a regional scale, potentiometric surface mapping shows that groundwater in the bedrock often is in hydraulic communication with alluvial aquifers. These shallow aquifers discharge as springs and seeps along the valley bottom and in the active channel of the Yellowstone River and its tributaries. Groundwater from the Fox Hills–lower Hell Creek Aquifer and other sandstone aquifers discharge in topographically lower areas by upward leakage to shallower aquifers and streams (Smith et. al., 2000).

OTHER BEDROCK AQUIFERS

Other geologic formations that are aquifers in other parts of the state are utilized minimally or not at all in the Yellowstone basin because they are deeply buried or have very limited surface exposure. These include the Wasatch Formation, Falls River Formation, Kootenai Formation, Swift Formation, Chugwater Formation, Tensleep Formation, Amesden Formations, and the Madison Group.

Groundwater occurrence within bedrock aquifers (Precambrian rocks, Madison Group, Cretaceous Livingston Group, Absaroka volcanics, Elkhorn Mountain volcanics, and other volcanic material aquifers) are primarily found in discontinuous fractures and faults, resulting in large variations in well yield, often over short distances. Fracture generally is not sufficiently continuous to create regional-scale aquifers; however, fracturing is often sufficient to yield adequate water supplies for individual residential or small public water supplies with multiple wells. On a regional scale, potentiometric surface mapping shows that groundwater in the

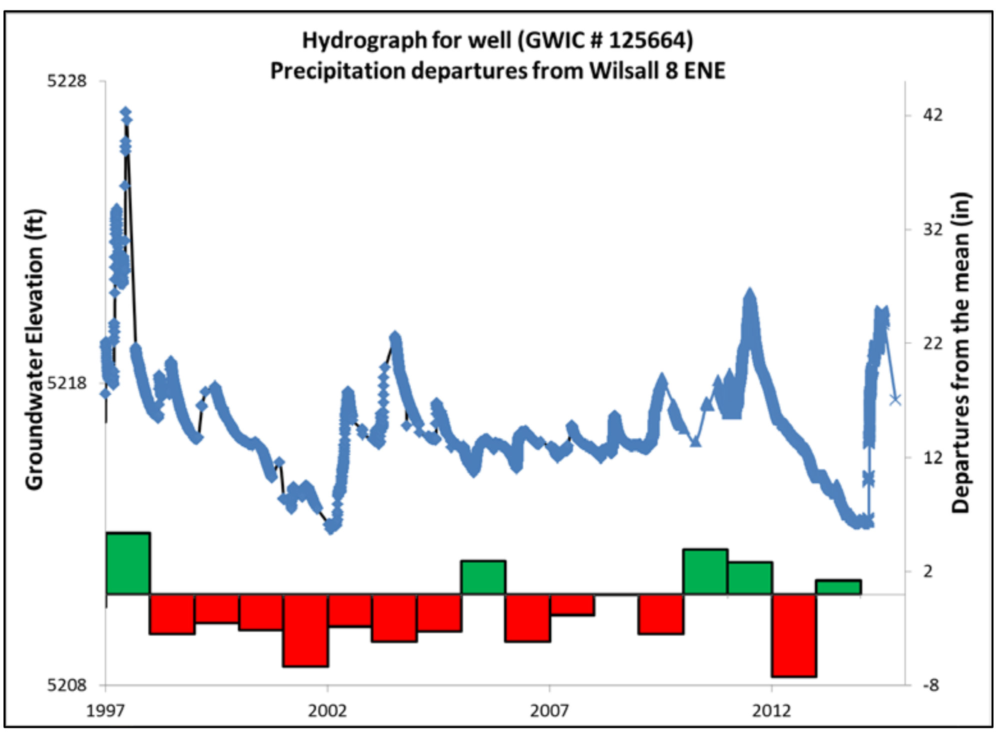


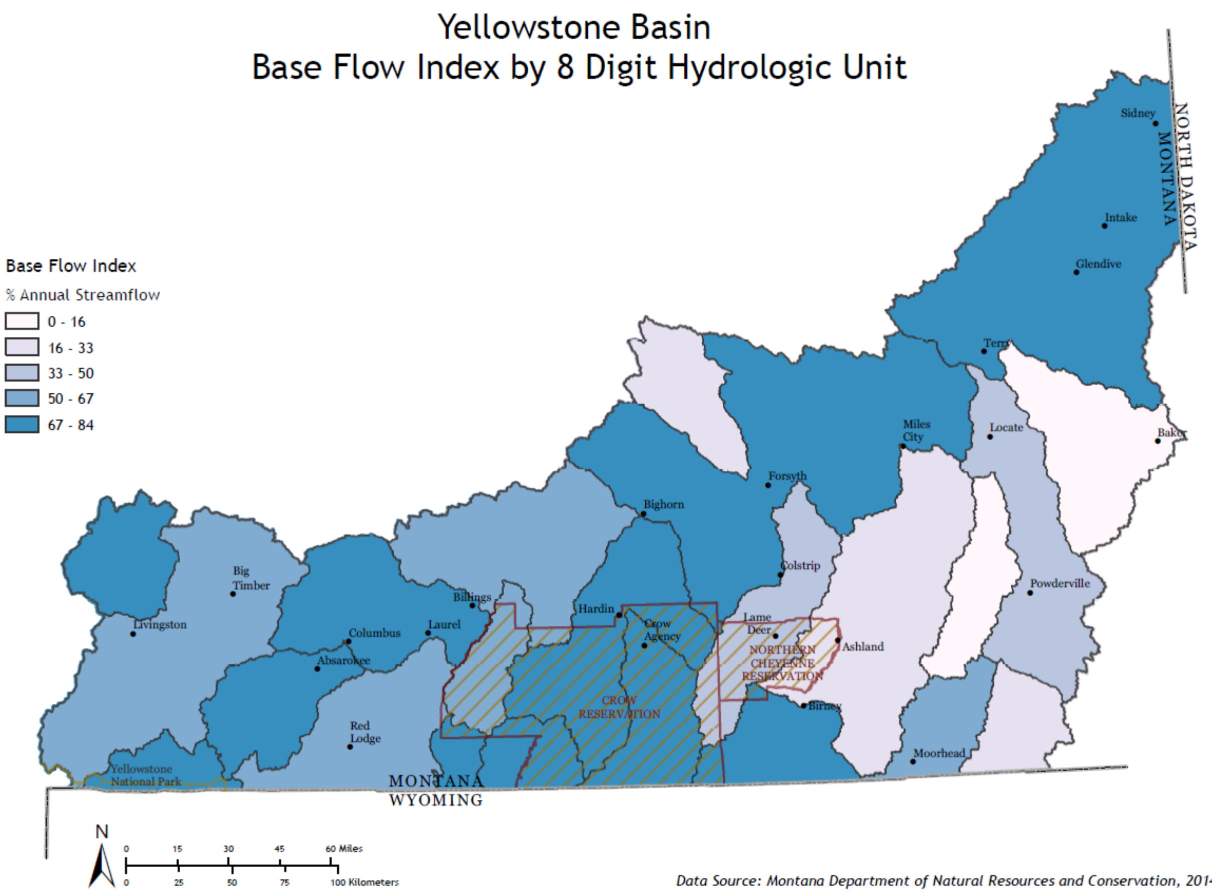
Figure IV-38 Water level in a well (GWIC # 125664) completed in the Livingston Group Aquifer near Wilsall.

bedrock is often in hydraulic communication with alluvial aquifer. Figure IV-38 shows the seasonal variation in groundwater trends in a shallow aquifer system of the Livingston Group. These groundwater trends are related to groundwater pumping, recharge, and climate variability.

GROUNDWATER BASE FLOW CONTRIBUTION

The contribution of groundwater to surface water base flow (Figure IV-39) is derived from Base Flow Index (BFI) information from Wolock (2003A). 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, 2003B). 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, 2003C). 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 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 Wolock (2003A) are based on surface water base flow estimates and, therefore, rely on assumptions that groundwater does not leave a basin through regional groundwater flow. BFI values are highest along the Yellowstone River corridor and certain tributaries including the Bighorn River.

Figure IV-39 Generalized map of base flow index.

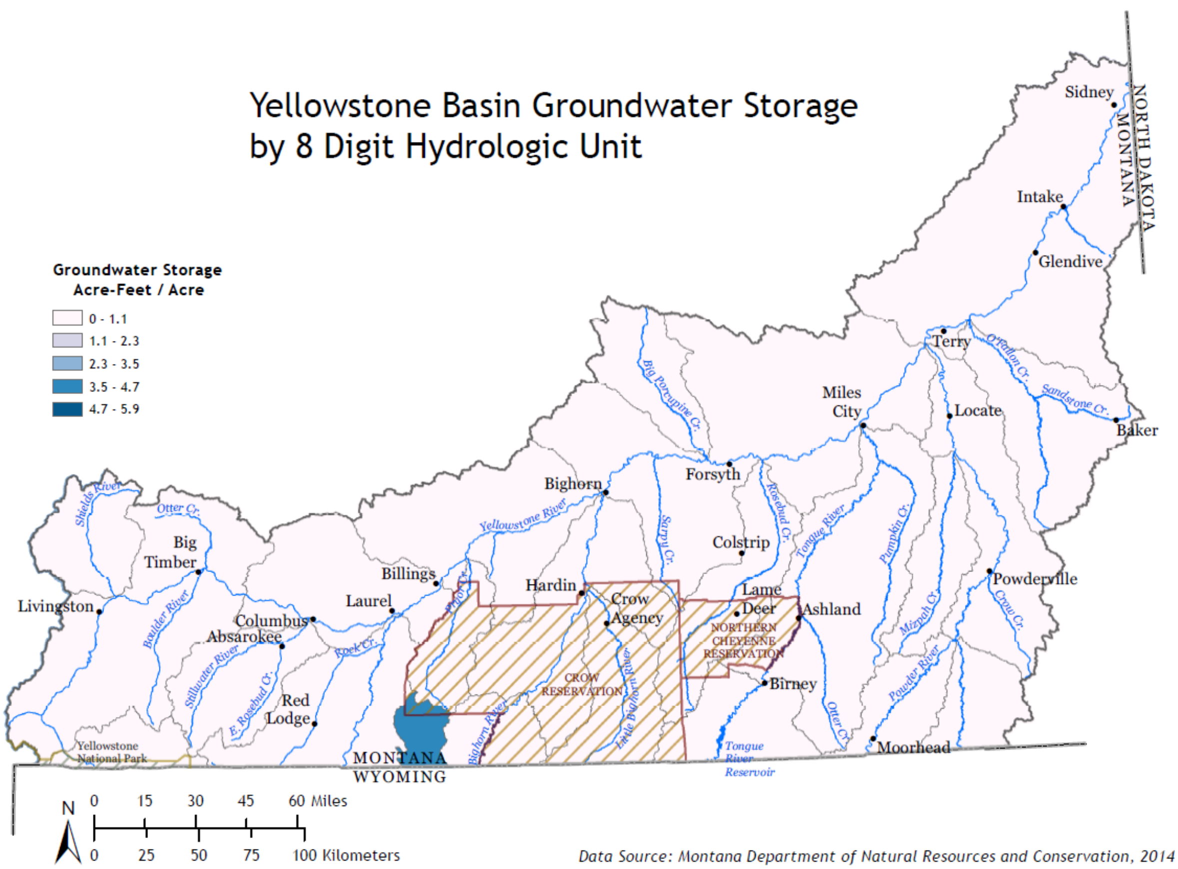


GROUNDWATER STORAGE

The groundwater storage capacity (Figure IV-40) 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 and alluvial terraces sediments with the primary rock type identified as coarse grained is obtained from a digital geologic map available from the 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 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.

Figure IV-40 Groundwater storage (acre-feet per acre) estimates in the upper 50 feet of saturated thickness of alluvium/basin-fill aquifer.



OPPORTUNITIES FOR RESEARCH AND INVESTMENT

The following groundwater data gaps and areas of uncertainty were found.

1. Groundwater/surface water interaction studies are needed in the Yellowstone River basin and its tributaries to examine how groundwater production affects surface water flows in these watersheds.
2. More information (baseline data of water levels and quality, additional long-term monitoring wells, and increased model accuracy) is needed for the development of bedrock groundwater sources for irrigation purposes and to understand the implications of such development on deep aquifers.
3. Ancestral Yellowstone River channels aquifer studies are needed to collect baseline data for groundwater model development for the Yellowstone River Basin.
4. Fort Union Formation Aquifer studies are needed to collect baseline data for groundwater model development for the Lower Yellowstone River sub-basin.
5. The groundwater model for the Fox Hills–Hell Creek Aquifer should be completed for the entire areal extent of the aquifer in the state of Montana.
6. Need to examine the correlation of the number of new Fox Hills–Hell Creek wells and their use to the groundwater declines estimated in the aforementioned model.
7. Additional studies are needed to evaluate the changes in groundwater systems due to conversion from flood to center pivot irrigation.
    a. Need to examine the cumulative impacts of exempt wells on surface water and other groundwater users.

Addressing these data gaps will provide a wealth of knowledge that will be of great use to scientists, water users, and anybody responsible for water policy decisions.

SOURCES OF GROUNDWATER INFORMATION

Information on the distribution and properties of aquifers is based on review of reports published by the MBMG and the USGS, master's theses, reports prepared by consultants for water right applications, and other documents included in the references. Maps and reports published by MBMG under the Ground Water Characterization Program (GWCP) summarize available information and present maps and cross-sections of aquifers, and maps and hydrographs of groundwater levels and water quality. Groundwater level and water quality data are housed in the GWIC database developed and managed by MBMG or 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. Current projects within the Yellowstone Basin include a buried Yellowstone River channel aquifer study near Sidney and a coalbed methane groundwater model in southeastern Montana. Additional prospective GWIP projects can be proposed and are ranked for consideration by the Groundwater Assessment Steering Committee.

Water Quality in the Yellowstone River Basin

Introduction

The quality of water in the Yellowstone River Basin is highly variable with large contrasts between the humid forested headwaters and the sparsely vegetated, semi-arid plains. Water quality is typically described by a set of physical, chemical and biological measurements (Table IV-4). The quality of groundwater in shallow alluvial aquifers is generally similar to that of local surface water, while the quality of water in deeper bedrock aquifers is more strongly influenced by rock composition and the age of the water.

Table IV-4 Physical, Chemical and Biological Measurements that Describe Water Quality

Type of Water Quality	Water Quality Measurement	Description	Concern at Elevated Levels
Physical	Specific conductance (EC)	Electrical conductivity of water	may cause harm humans, livestock, plant growth
	Dissolved Solids (TDS)	Concentration of dissolved ions[1]water	may cause harm to humans, livestock, plant growth
	Sodium Adsorption Ratio (SAR)	Relative concentration of sodium in water	may cause harm to livestock, plant growth, and soil tilth
	Suspended-Sediment (SS)	Concentration of fine sediment in water	may cause harm to aquatic life and irrigation systems
	Turbidity (T)	Visual clarity of water	May cause harm to aquatic life and irrigation systems
	Water Temperature (WT)	Temperature of water	May cause harm to aquatic life
Chemical			
	pH	acidity of water	May cause harm to humans, livestock aquatic life; affects solubility of nutrients and metals
	Dissolved oxygen (DO)	concentration of oxygen dissolved in water	
	Biochemical oxygen demand (BOD)	Amount of oxygen consumed by biota in water	
	Total hardness (TH)	Sum of hardness due to calcium and magnesium	May cause scale in plumbing, boilers, and irrigation systems
	Heavy Metals	Concentration of heavy metals[1]in water	May cause harm to humans, livestock and aquatic life
	Nitrate	Concentration of nitrate in water	May cause harm to humans, livestock and aquatic life
	Orthophosphates	concentration of "reactive phosphorous" in water	Affects growth of algae
	Pesticides/Herbicides	concentration of pesticides or herbicides in water	May cause harm to humans, livestock and aquatic life
Biological			
	E. coli		May cause harm to humans, livestock and aquatic life
	Coliform bacteria		May cause harm to humans, livestock and aquatic life
		Biological Indicators of Water Quality	
		Aquatic insects	
		Benthic macroinvertbrates	

[1]Major ions include sodium, calcium, magnesium, bicarbonate, sulphate, cloride and silica; Minor ions include iron, potassium, carbonate, fluoride and boron.

[2]Heavy metals include chromium, cobalt, nickel, copper, zinc, arsenic, selenium, silver, cadmium, antimony, mercury, thallium and lead.

MONTANA WATER QUALITY LAW

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.

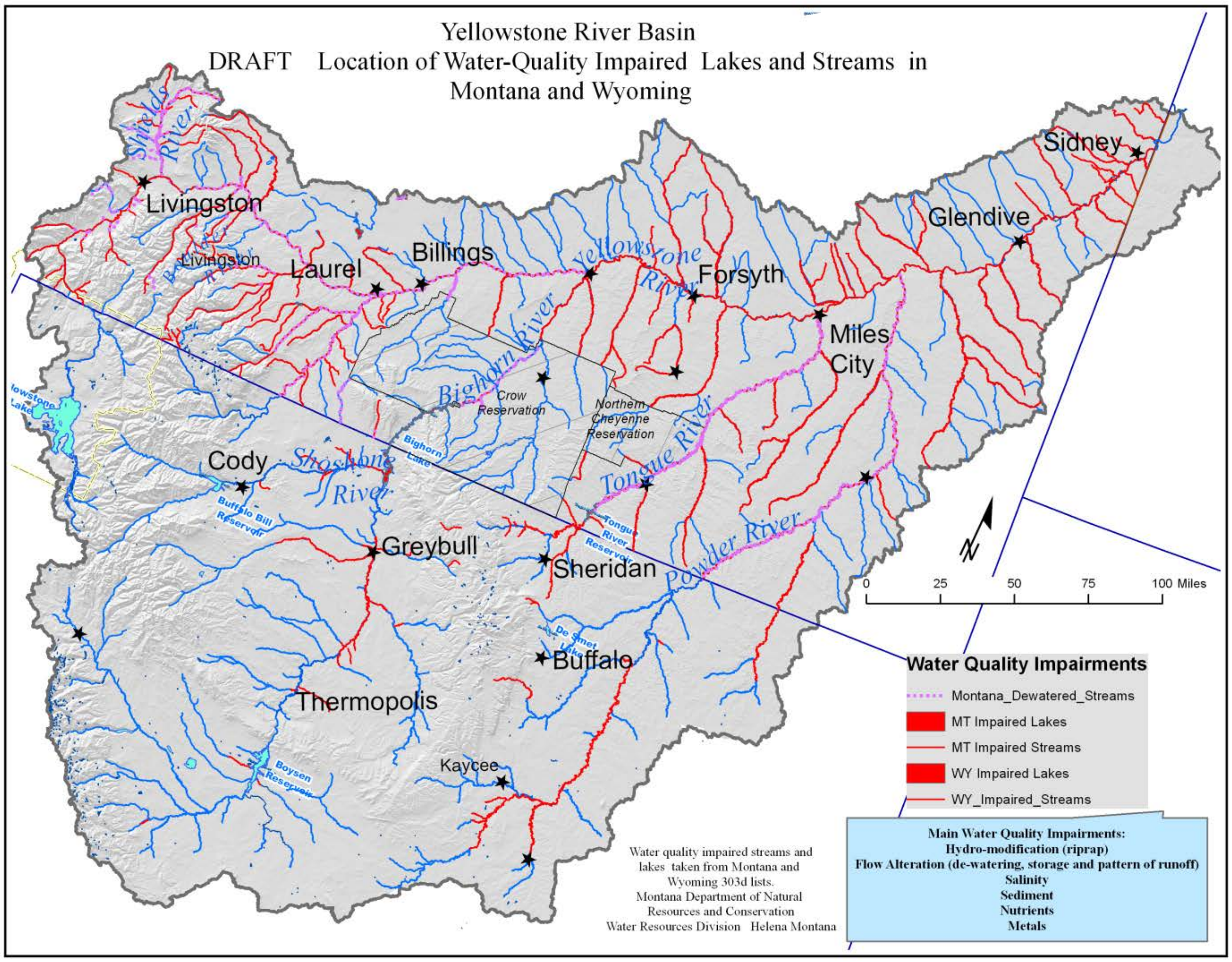
The 1972 federal Clean Water Act established a national framework for protecting and improving water quality. Sections of the Clean Water Act passed in 1987, Sections 303(d) and 305(b), require states to monitor and assess statewide water quality conditions, identify and list waterbodies that fail to meet water quality standards, and prepare Water Quality Improvement Plans for restoring water quality. These plans 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 pollution.

In the 1950s, Montana classified its waterbodies according to the present and future beneficial uses they should be capable of supporting. Montana's water use classification system identifies the following beneficial uses—listed in order of highest to lowest quality (MTDEQ 2014):

1. drinking, culinary, and food processing
2. aquatic life support for fishes and associated aquatic life, waterfowl, and furbearers
3. bathing, swimming, and recreation
4. agricultural water supply
5. industrial water supply

The MTDEQ prepares a Integrated Report and 303(d) List, that is submitted to EPA every two years; this report lists streams, lakes and reservoirs that are impaired and do not meet the beneficial uses for a particular water body (Figure IV-41). (Appendix E, Section IV. Water Quality).

Figure IV-41 Water quality impaired streams in the Yellowstone River Basin.



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, comprising 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 nonpoint pollution (from Table 4-1, DEQ, 2012). DEQ estimates that approximately 37 percent of the state’s perennial river and stream miles, and 72 percent of the lake and reservoir acres, have been assessed.

The Nonpoint Source 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, and federal agencies; and individual Montanans to provide training, monitoring support, and project funding. For those waters not meeting standards, total maximum daily loads (TMDLs) are developed, followed by voluntary implementation of best management practices for nonpoint sources, and potentially, point source permit waste load allocations. 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. TMDL activity in the Yellowstone River Basin includes the following:

As of March 20, 2014, the only active TMDL projects in the Yellowstone are within the Tongue and Powder watersheds. That work is mostly involved with detailed salinity modeling to help inform future TMDL development activities, with higher priority within the Tongue and specifically within Otter Creek (a tributary of the Tongue). The work in Otter Creek also involves development of an iron TMDL and removal of a sediment impairment due to a non-impairment determination jointly determined via DEQ and EPA coordination. This work is scheduled for completion in 2014.

TMDLs have been completed for parts of the Cooke City area, the Shields River watershed, and the Boulder River. TMDL documents may be downloaded from DEQ's TMDL website: http://deq.mt.gov/wqinfo/tmdl/default.mcpx

Site-specific nutrient standards for the Yellowstone River are complete or nearing completion. This will assist with future nutrient assessment updates and any resulting TMDL activity. DEQ is in the process of prioritizing TMDL activity for the next 2 to 5 years. The Tongue, Powder, and Rosebud watersheds are currently identified as TMDL development priority areas. No other areas within the Yellowstone watershed are currently identified as a priority, but that could change and DEQ is interested in hearing from stakeholders regarding areas where there is interest in implementing the type of water quality protection activities typically recommended within a TMDL document. 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 waterbodies receiving point source discharges from sewage, industrial, or other waste sources.

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, the Montana Dept. of Fish, Wildlife and Parks regulates government activities that disturb the bed or banks of streams. 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, the Montana Department of Environmental Quality (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 to develop and enforce 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. Figure IV-41 shows a map of water quality impaired streams in the Yellowstone River Basin.

U.S. GEOLOGICAL SURVEY NATIONAL WATER QUALITY ASSESSMENT (NAWQA)

As part of its National Water Quality Assessment, the U.S. Geological Survey has identified several major water-quality issues in the Yellowstone River Basin (Table IV-5).

Table IV-5 Major Water Quality Issues in the Yellowstone River Basin

Trace Elements	Leachate from mine spoils and tailings can increase trace elements in both ground water and streams. Leaching of soils derived from marine shales of Cretaceous age in some locations has caused high concentrations of selenium in water resources. Geothermal
Toxic compounds	Potential sources for toxic compounds in both ground water and streams include: leachate from abandoned and active landfills; pesticides, herbicides and fertilizers from lawns and croplands; hydrocarbons from leaking tanks, refining operations, pipelines, and spills;
Salinity	Increases in the salinity of both ground water and streams can occur from saline ground water disposal, irrigation return flows, and some irrigation practices.
Sedimentation	Loss of streambank vegetation, easily erodible soils, and many land-use activities can contribute to sediment problems in streams throughout the basin.
Bacteria	Fecal coliform bacteria concentrations can exceed water-quality guidelines for streams. New guidelines are being considered for Escherichia coli, a species of bacteria associated with waste from warm-blooded animals.
Nutrient concentrations	Nutrient concentrations in streams can exceed guidelines for the prevention of nuisance algal growths. Excessive concentrations of algae can result in inadequate dissolved-oxygen concentrations and harmful effects to aquatic life, as well as impeding aes
Low-density residential development	Low-density residential development in the outskirts of communities has the potential to affect ground-water quality in these areas. Potential influences include leachate from septic systems; fertilizer and pesticide use on lawns, pastures, and gardens;
Other	There are many other water-quality issues in the basin including: acidification of water resources by leaching of industrial wastes, increased concentrations of nutrients in surface and ground water, localized de-watering of sole-source aquifers, potentia

Source: U.S. Geological Survey (1997) National Water-Quality Assessment Program- Yellowstone River Basin. Fact Sheet 149-97

The ongoing USGS NAWQA study found that in Yellowstone Basin surface water:

1. Concentrations of fecal coliform bacteria and Escherichia coli, which are indicators of fecal matter from warm-blooded animals, were higher in urban and agricultural streams than in forested or rangeland streams. Almost 40 percent of bacteria concentrations exceeded the Federal recreational criterion for moderate use.

2. Concentrations of total phosphorus in streams in the basins and plains, such as the Clarks Fork Yellowstone, Little Powder, and Powder Rivers, were elevated compared to those measured in other streams across the Nation, due in part to natural sources (p. 12). Phosphorus concentrations at most sampling sites exceeded the Federal goal of 0.1 milligram per liter for minimizing nuisance plant growth in flowing waters.
3. Herbicides and their breakdown products were detected frequently in streams, but at low concentrations compared to national levels (p. 15). Organochlorine compounds were detected in many fish tissue samples and in one bed-sediment sample; concentrations generally were less than guidelines for the protection of wildlife.
4. Concentrations of trace elements in surface and ground water generally were less than guidelines for human health, but concentrations of selenium in some water samples indicated possible adverse effects to biota. Trace-element concentrations in bed sediment from mineralized areas (rock formations with high concentrations of minerals and trace elements) exceeded background levels and were large enough to possibly affect aquatic life.
5. Biological communities are degraded in some segments of the Yellowstone River. Algal, invertebrate, and fish communities in the segments near Billings and Forsyth were most affected. (Peterson and others, 2004).

The USGS NAWQA study also examined groundwater and found that:

A. Concentrations of radon in 52 of 54 ground-water samples exceeded a proposed Federal drinking-water standard of 300 picocuries per liter. The radon concentrations also were high compared to those measured in other ground-water systems measured across the Nation.

B. Concentrations of bacteria, nitrate, and trace elements in ground water generally were less than human-health guidelines. Less than 10 percent of the measured nitrate concentrations exceeded the Federal drinking-water standard of 10 milligrams per liter.

C. Pesticides were detected more often in the shallow Quaternary aquifers than in the underlying lower Tertiary aquifers. The pesticides most frequently detected in ground water were atrazine and prometon

D. Volatile organic compounds, many of which are associated with gasoline, were detected frequently in samples from the Quaternary aquifers and, to a lesser extent, the lower Tertiary aquifers. The concentrations were low compared to Federal drinking-water standards (p. 18). (Peterson and others, 2004).

Several figures follow that summarize key findings of the ongoing USGS Yellowstone NAWQA study. Additional figures are reproduced in Appendix E, Section IV. Water Quality: U.S. Geological Survey Information.

An additional water quality problem that affects aquatic life in the Bighorn River is gas supersaturation in outflow from Yellowtail Dam and Afterbay. This problem is ongoing and occurs when atmospheric gasses, especially nitrogen, are entrained in plunging water and absorbed by fish before the gas can dissipate. When nitrogen levels exceed normal levels and affect a trout's gills and other vital organs, death can occur. The U.S. Bureau of Reclamation and Montana Fish Wildlife and Parks monitor and manage the problem.

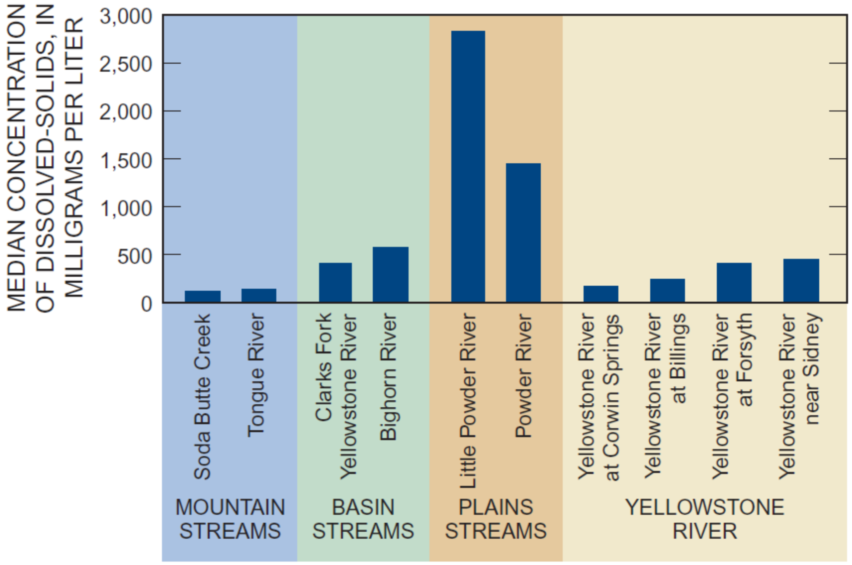


Figure IV-42 The concentration of dissolved solids (a measure of stream salinity) are lower in mountain streams than in larger basin and plains streams. Salinity in the Powder River drainage limits agricultural use. (Graph from Peterson and others, 2004.)

Water from study unit aquifers was more mineralized than water from other aquifers in the Nation

Concentrations of dissolved solids in both aquifers sampled in the Yellowstone River Basin were higher than in most shallow wells sampled elsewhere in the Nation. The median concentrations of dissolved solids of 956 mg/L for samples from the Quaternary aquifers and 1,302 mg/L for samples from the lower Tertiary aquifers were much higher than the median of 280 mg/L from 2,391 domestic wells sampled nationally as part of the NAWQA Program from 1991 to 2001.

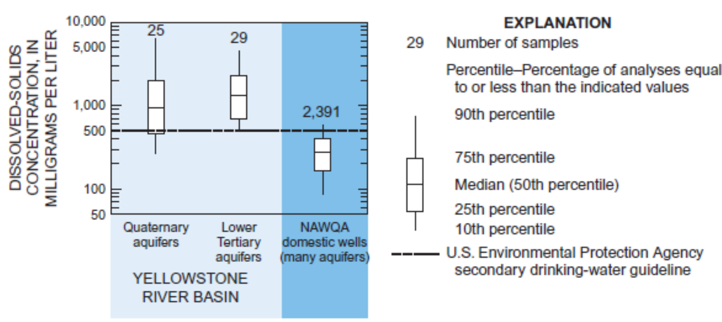


Figure IV-43 Concentration of dissolved solids in Yellowstone River Basin aquifers (Source: Peterson and others, 2004.)

Figure IV-44 The concentration of dissolved arsenic in surface water of the Yellowstone River Basin is elevated due to geothermal sources in Yellowstone National Park (Source: Peterson and others, 2004).

Median concentrations of dissolved arsenic in samples from the Yellowstone River at Corwin Springs and at Billings exceeded the USEPA drinking-water standard of 10 micrograms per liter (graph B), probably because of the natural occurrence of arsenic in geothermal waters (Hem, 1985). In streams in and around Yellowstone National Park, arsenic remains in solution (Nimick and others, 1998). Downstream decreases in the concentration of arsenic—from Corwin Springs to Sidney—probably result from increased dilution by tributary inflows.

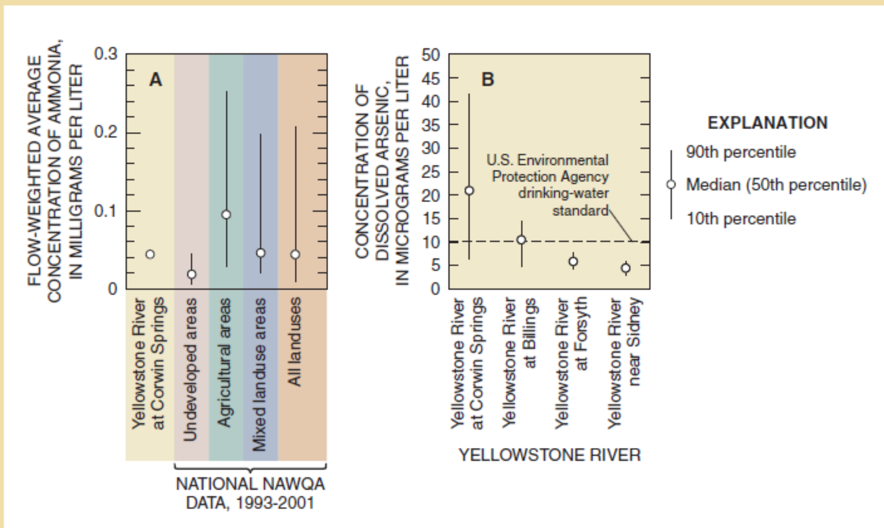
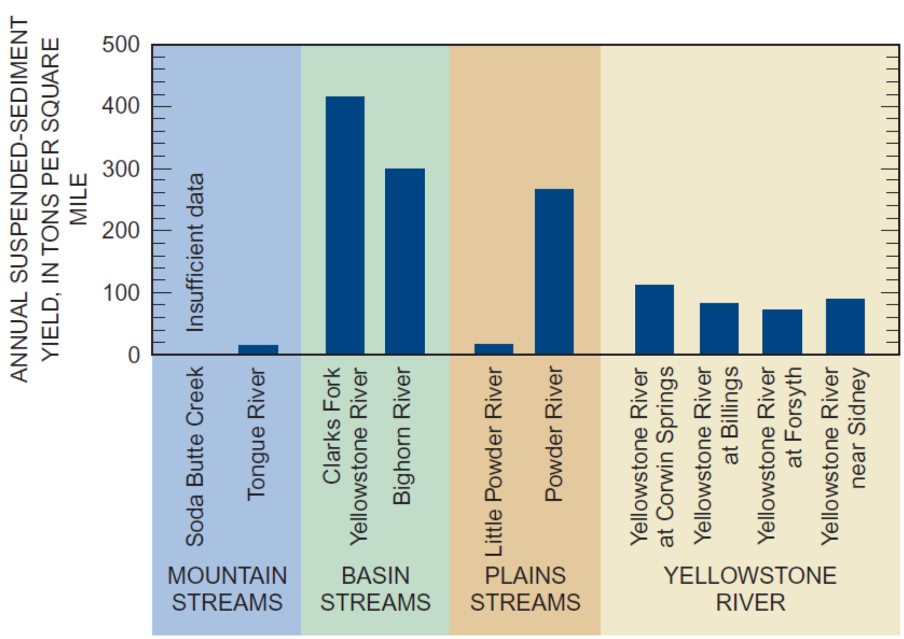


Figure IV-45 Mountain streams with more humid climates and vegetation have smaller sediment yields than basin and plains streams with little vegetation and soils susceptible to erosion (Source: Peterson and others, 2004).



All water naturally contains dissolved solids as a result of weathering processes in rocks and soils. Certain human activities can increase dissolved-solids concentrations above natural levels. Major ions, such as bicarbonate, calcium, chloride, magnesium, potassium, silica, sodium, and sulfate constitute most of the dissolved solids in water and are an indicator of salinity. Some amount of dissolved solids is necessary for agricultural, domestic, and industrial water uses and for plant and animal growth. Many of the major ions are essential to life and provide vital nutritional functions. Dissolved solids are also fundamental in numerous products and processes, such as nutritional supplements, water conditioning, food seasoning and production, cleaning products, fertilizers, road deicers, and in the manufacturing, chemical, and electronics industries. Excessive dissolved-solids concentrations in water, however, can have adverse effects on the environment and on agricultural, domestic, municipal, and industrial water users.

Water quality may limit future consumptive development in the Yellowstone basin in several ways. In semi-arid portions of the basin, salinity and specific-ion composition (as measured by adjusted sodium adsorption ratio) place chemical and physical limits on irrigation water suitability--beyond a point, applied water causes more harm than good and crop yield and soil productivity decline. Generally these limits are much less restrictive than for other beneficial uses such as public water supplies, fisheries and recreation. At some level of consumptive development, the cumulative effect will approach these less restrictive limits, violate Montana or Wyoming water quality standards, and the salt and sodium concentrations will limit further consumptive use.

Water quality is an important issue in both the Tongue and Powder River drainages with existing levels of development. The Tongue River supports a warm water fishery (coldwater immediately below Tongue River Dam), and water quality as it relates to instream flow and aquatic life is a concern. In the Powder River drainage (Montana portion) where salinity loads are typically 2 to 3 times larger than the Tongue River, quality limits the suitability of water for irrigation. Chemical water quality is less of a concern in the Clarks Fork basin because of the relatively plentiful water supply and moderate dissolved solids load--the Clarks Fork does have a significant suspended-sediment load related to both natural and agricultural sources. Within the Big Horn basin in Montana water quality does not currently limit beneficial uses of water.

Another consideration is the large sediment load of the Powder River (8,000,000 tons/year at Moorehead, Mt). In addition to limiting the feasibility of mainstem storage, the excessive sediment load requires that the need for channel maintenance or "flushing" flows be examined. The justification is based on the fact that extensive flow depletion or regulation can alter downstream channel stability with deleterious effects, including: impaired performance of the water supply system resulting in the need to modify location and design of diversions and canals; loss of land and modification of access due to channel migration; and increased maintenance of civil works such as bridges.

USGS WATER-QUALITY TREND STUDIES

The Tongue and Powder River watersheds overlie the Powder River structural basin (PRB) in northeastern Wyoming and southeastern Montana. Limited extraction of coal-bed methane (CBM) from the PRB began in the early 1990’s, and increased dramatically during the late 1990’s and early 2000’s. CBM-extraction activities produce discharges of water with high concentrations of dissolved solids (particularly sodium and bicarbonate ions) relative to most stream water in the Tongue and Powder River watersheds. Water-quality of CBM-produced water is of concern due to potential effects of sodium on agricultural soils and potential effects of bicarbonate on aquatic biota.

Several recent studies have characterized water-quality and analyzed temporal trends in water-quality constituents in the Powder River (Clark and Mason, 2007; Wang and others, 2007; Clark, 2012) and Tongue River (Clark and Mason, 2007; Clark, 2012) watersheds. These studies primarily focused on stream sites in Wyoming, with less emphasis in Montana. An exception is the synoptic study by Kinsey and Nimick (2011), who quantified dissolved-solids and sodium loading between the Tongue River at Monarch, WY and Tongue River near the upstream end of Tongue River Reservoir. They found that CBM outfalls in the study reach could increase specific conductance by about four to 16 percent , and SAR from 39 to 1512 percent, at low flow (100 cfs); at a higher flow of 600 cfs, CBM discharges could increase specific conductance from 2 to 8 percent and SAR by 21 to 79 percent.

The U.S. Geological Survey recently analyzed stream flow and water quality data in the Tongue and Powder River basins of Montana and Wyoming (Sando, S.K. and others 2014). In the Powder River they found that over the years 1986-1995 state line values of SAR, sodium, estimated alkalinity, chloride and specific conductance, decreased in response to Salt Creek (WY) oil-brine reinjection that started in 1990. In the subsequent time period (2001-2010), trend results for all main stem Powder River sites downstream from substantial CBM-extraction activities show evidence of potential effects of CBM-extraction activities on stream water quality, with the strongest evidence for the Powder River at Sussex, WY and at Moorehead, MT.

(See Appendix E, Section IV. Powder and Tongue River Water Quality Trend.)

V. Water Use in the Yellowstone Basin

Historical Water Use in the Yellowstone Basin

(The information below is taken from Greenfields of Montana - A Brief History of Irrigation by Stanley W. Howard, 1992)

PRE-1900

The early 1880s found settlers moving into the Yellowstone and Lower Yellowstone Valleys, and along its tributaries. A typical early settler who made use of Yellowstone water was John Young. He built his log cabin in 1877 on the bank of the Yellowstone River at Young's Point, about four miles west of present-day Park City. Several others moved into the area between Park City and Billings at about the same time. Little did they realize that the area would someday become one of the most productive irrigated valleys of Montana. Young's site was sub-irrigated and he grew potatoes.

The area around Billings settled rapidly, according to historical reports. In 1873, the land had no white residents; by 1883, a population claimed to be several thousand having property with and assessed valuation of nearly $2 million supported the request for county designation, and Yellowstone County was formed.

George Mace settled west of Forsyth in present-day Rosebud County in 1876. He entered into a government contract near the mouth of Reservation Creek in about 1881, and developed one of the first irrigation projects in Rosebud County. He built a diversion dam on Reservation Creek and constructed a canal to divert water to irrigate his claim. He grew alfalfa hay from seed imported from California.

Emmett Dunlap had settled on Dunlap Creek in the Lower Yellowstone Valley near present-day Savage. An issue of the *Glendive Times* in 1889 described Dunlap's ranch as an illustration of what could be obtained by irrigation. The ditch provided water for 160 acres of hay. Testimony at the Senate Irrigation and Reclamation Committee hearing in Glendive on August 6, 1889 indicates that Dunlap's farm produced corn, potatoes, oats, and many kinds of vegetables.

The Minnesota and Montana Land and Improvement Company (a subsidiary of the Northern Pacific Railway), provides an early example of private construction. Its purpose was to irrigate the town site of Billings and land adjacent to or near the Clarks Fork and Yellowstone Rivers. This project diverted 20,000 miner's inches (5,000 cfs) of water from the Yellowstone River. The canal's construction required a great number of structures, all built of wood, including the head gate and nine flumes. Because the canal system was large for that era, it was later called the "Big Ditch". Eventually, between 30,000 and 35,000 acres were irrigated.

The Miles City Irrigation and Ditch Company was incorporated in 1885 under the laws of the Territory of Montana to divert water from the Tongue and Yellowstone Rivers. The company was incorporated for 20 years and its purpose was "irrigation, milling or town supply."

POST- 1900

Two projects under the Newlands Reclamation Act were built by the USBR: The Lower Yellowstone and Huntley Projects. The Lower Yellowstone Project, authorized in 1904, diverts about 1,500 cfs from the Yellowstone River below Glendive at Intake. The diversion dam and 67-mile canal were begun in 1905, with project land receiving water in 1909. Today, the project irrigates about 60,000 acres. Construction of the Huntley project east of

Billings began in the year of authorization, 1905, and the first water was delivered in 1909. The portion of the canal that crosses Pryor Creek has been washed out by floods on Pryor Creek and rebuilt three times. Today, the Huntley Project waters about 30,000 acres of alfalfa and other hay crops, sugar beets, silage, irrigated pasture, and small grains.

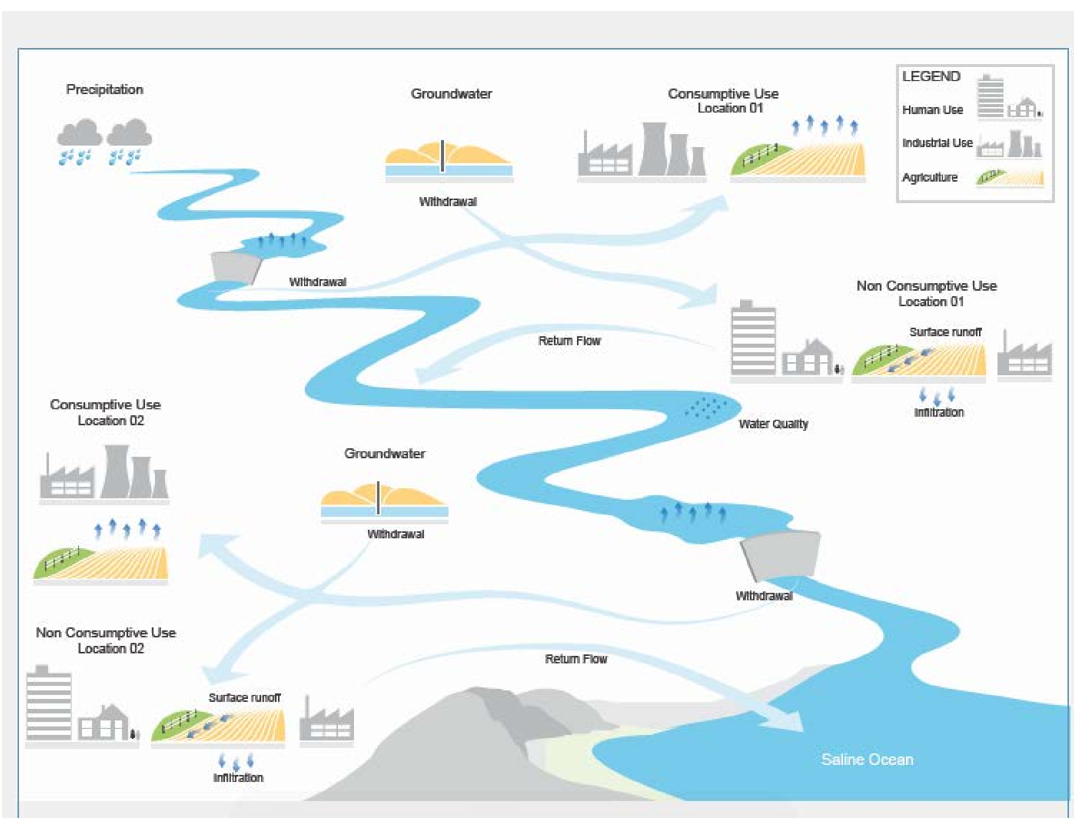
Inventory of Consumptive Water Use in the Yellowstone Basin

OVERVIEW OF CONSUMPTIVE AND NON-CONSUMPTIVE USE

Consumptive water use in Montana is influenced by a variety of factors including irrigated acreage, physically available water supplies, number of stock, and population. The water volume consumed by any use is less than the volume initially diverted, and the unused portion of water eventually returns to the system to be used by others. In Montana, total consumption amounts to less than 30 percent of the diverted total, when considering all uses combined.

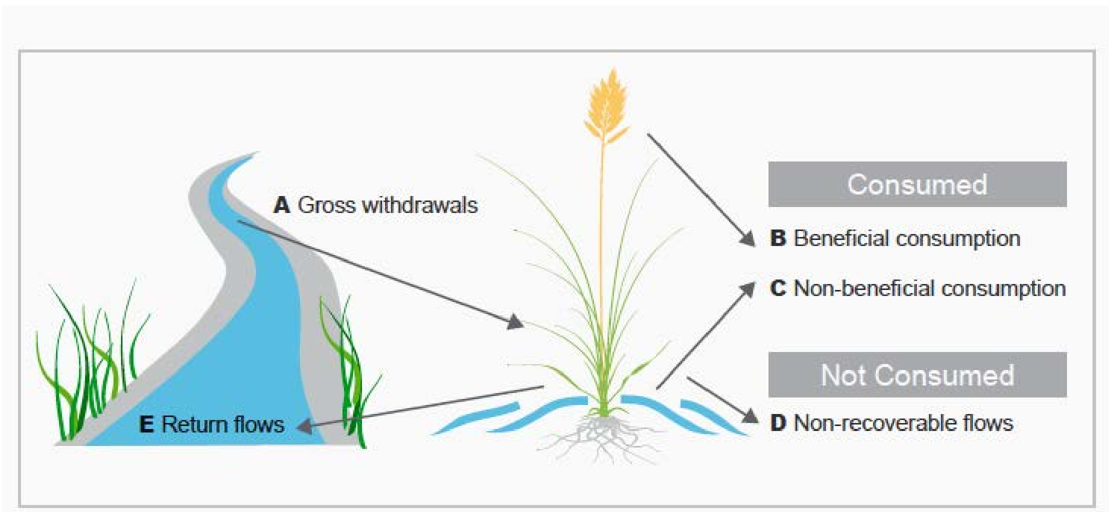
Water falls on the basin as precipitation and either runs off into the rivers (Figure V-1), infiltrates into the ground, or is returned to the atmosphere through evapotranspiration. It is commonly captured and stored for later use in storage projects or aquifers. Water is subsequently withdrawn from either the river or surface storage to meet demands which can be divided into two components: consumptive demand and non-consumptive demand.

Figure V-1 Hydrologic cycle and consumptive and non-consumptive uses of water.



Consumptive demand permanently removes water from the basin. Examples include evaporation from open water or cooling systems and evapotranspiration from crops and plants (Figure V-2). Non-consumptive demand is water that is either withdrawn for use but returned without being consumed (hydropower), or used instream without any means of diversion (fish and wildlife). Examples include hydropower generation, and instream flow. Water that is not consumed is returned to the basin. Depending on the soil, geology, and aquifer properties, this water may return rapidly (within days) or slowly (over months).

Figure V-2 Withdrawal (diversion) of water for consumptive and non-consumptive use.



PREVIOUS EFFORTS TO ESTIMATE WATER USE

Water use in the Yellowstone River Basin has been estimated in several previous investigations. DNRC estimated consumptive use throughout the Yellowstone Basin in the early 1980's as part of a water availability study conducted in support of the Yellowstone Water Reservations (Sobashinski and Lozovoy 1982). The Wyoming State Engineer's Office consultants estimated consumptive and non-consumptive uses of water in the Powder, Tongue and Wind-Clarks Fork-Bighorn Basins of Wyoming as part of its state water planning effort in the early 2000's. The USGS publishes estimates of water use in Montana every ten years (Cannon, M.R and D.R. Johnson, 2004).

Methodology, Scope and Purpose of Current Water Use Estimates

For the Montana State Water Plan, consumptive use of water was estimated for a variety of uses including, irrigated agriculture, livestock, municipal and domestic, and industrial. The methods for accomplishing this are described in Appendix F, Section V (Methods for Estimating Water Use for the State Water Plan). From this analysis and streamflow data for the period 1981-2010, partial water budgets were developed that summarize water use on an annual basis. The Yellowstone Basin's primary irrigated crops include alfalfa, barley, corn, grass, oats, and sugar beets. Agricultural water use varies across the basin and is affected by climate, geology and soils, and proximity to water.

For water accounting purposes and creation of generalized partial water budgets, the downstream point in each sub-basin is included in that sub-basin. For example, in the Upper Yellowstone sub-basin, Billings is the downstream location and the mean annual streamflow at Billings is used to represent the “total depleted inflow” to that sub-basin. The total depleted inflow is the amount of streamflow left in the channel after losses from consumptive use are accounted for. Estimated consumptive uses are then added to the depleted mean annual flow to arrive at an undepleted or “natural” flow. The depleted flow at Billings then becomes the inflow to the next basin downstream—the Middle Yellowstone sub-basin. This quantity represents the total inflow to the Middle Yellowstone, and with consumptive uses added back in, the undepleted streamflow added to that channel segment. This approach was taken so that consumptive uses in a sub-basin can be compared directly with the amount of inflow generated only in that sub-basin.

The partial water budgets examine only surface runoff and human consumptive uses of water—primarily irrigated agriculture. Other aspects of the water budget such as precipitation (snow and rain) and evaporative loss from land surfaces and evapotranspiration from vegetation are not accounted for. Further, effects of water storage (with the exception of evaporation) on main stem flow are not included, although the only basin with significant year-to-year, carry-over storage is the Bighorn.

WATER WITHDRAWALS AND CONSUMPTIVE USE BY IRRIGATED AGRICULTURE

Because irrigated agriculture is the largest consumptive user of water in the basin, these uses were estimated at the sub-basin scale. Irrigated land is largely restricted to alluvial floodplain areas or adjacent river terraces (Figure V-3.) and occupies a small percentage of the total basin area. A variety of irrigation methods are used including flood and sprinkler irrigation, with the latter method gaining increasing popularity over the past 20 years. Irrigated parcels were classified into four categories: flood irrigation, sprinkler irrigation (pivots), sprinkler irrigation (other types, such as wheel-line), and other types—primarily where classification information was lacking. Figure V-4 provides an example of the detail of the irrigated land mapping and classification that is not evident at the scale of Figure V-3.

Water use estimates by irrigated agriculture (Appendix F, Section V) were developed for the entire river basin (including Wyoming) at the sub-basin scale and are presented first; then water use estimates for irrigated agriculture for the entire basin in Montana are presented .

Figure V-3 Yellowstone River Basin Irrigated Land in Montana and Wyoming.

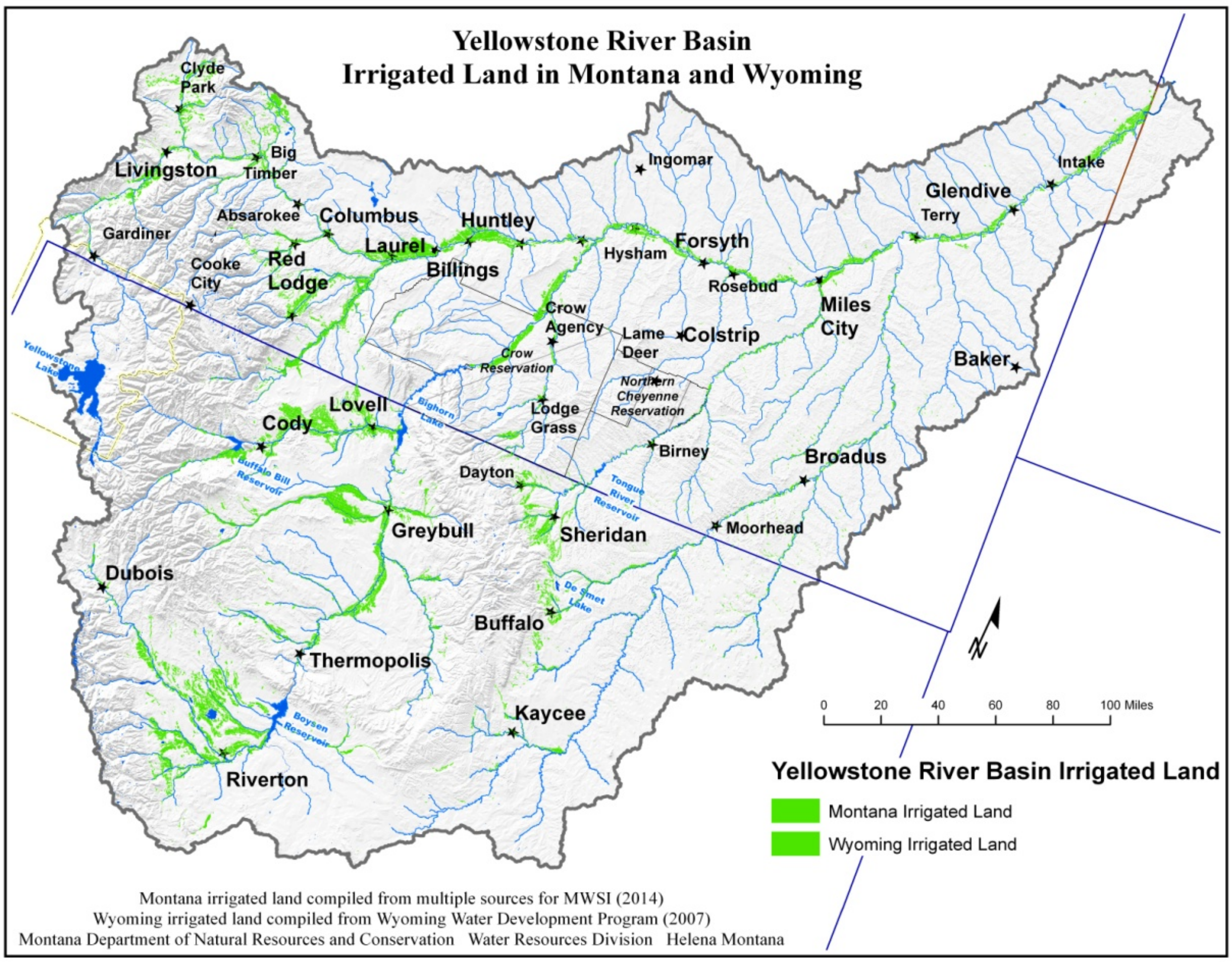
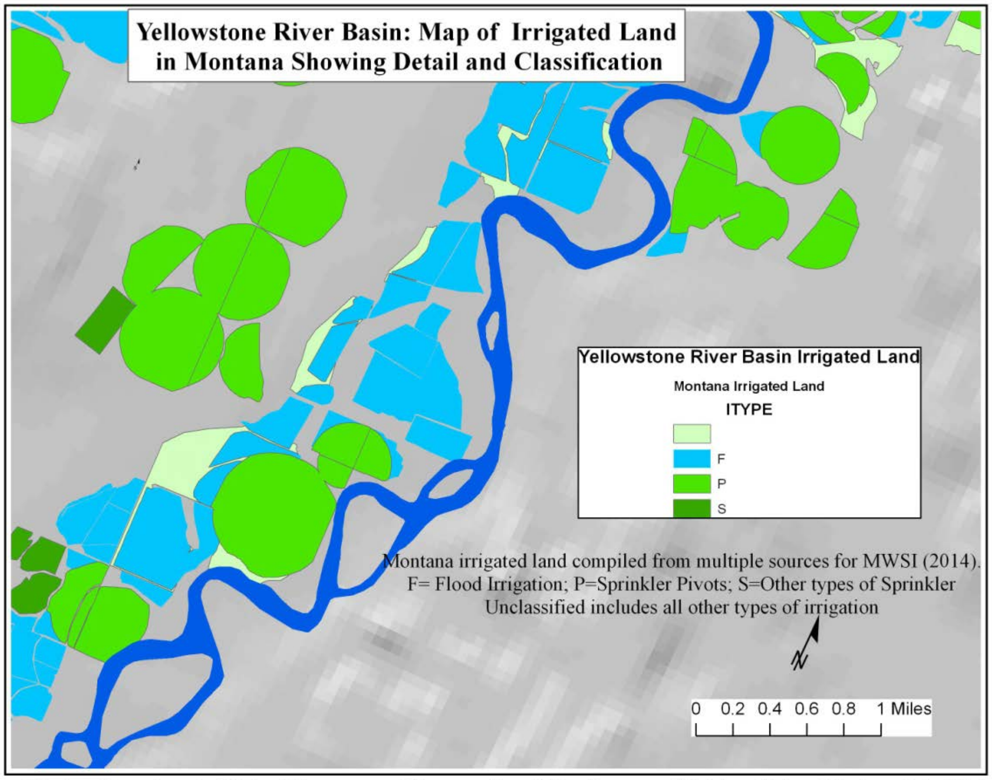


Figure V-4 Yellowstone River Basin Irrigated Land in Montana with Detailed Classification. Summary of withdrawals and consumption by use.

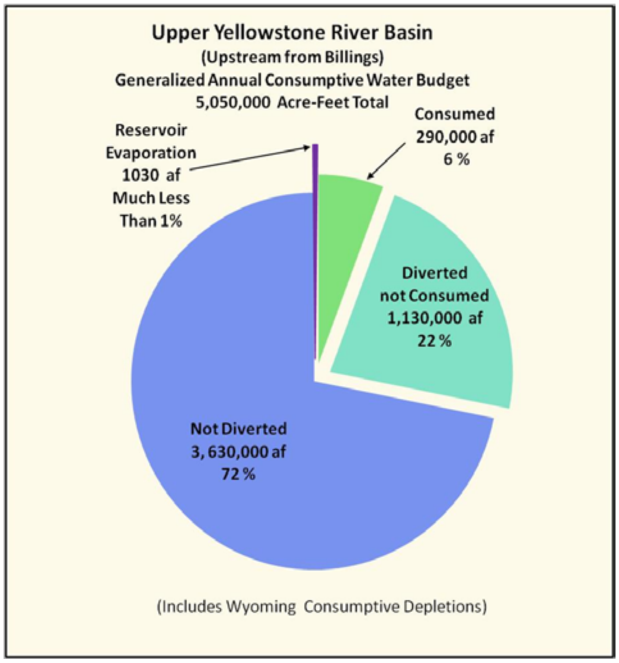


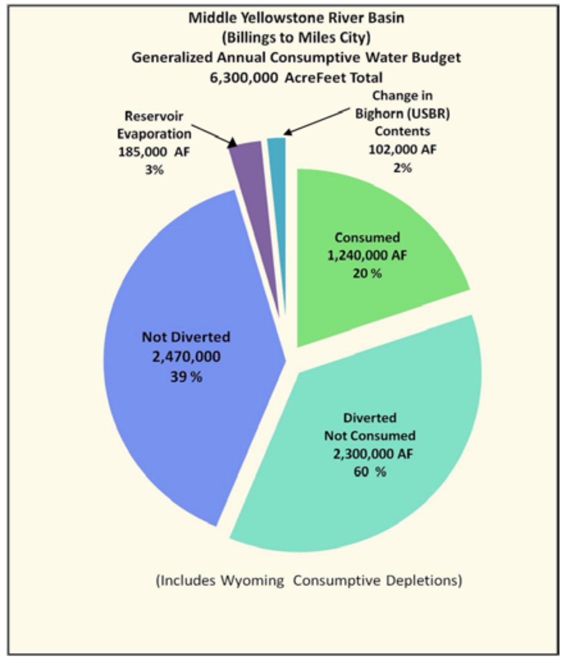
Montana Department of Natural Resources and Conservation Water Resources Division Helena Montana July 2014

The following pie-charts show generalized partial, annual water budgets for the major sub-basins in the Yellowstone River Basin. The water budgets are based on the streamflow at USGS gaging for an average (or median) year. For sub-basins where irrigation is heavily developed and there are sizable water storage projects, such as the Bighorn Basin, almost all of the water that is produced by the basin is captured or diverted at least once—especially during dry years. In the Upper Yellowstone Basin above Livingston, where there is relatively less irrigation and no storage, most flow is never diverted and during a typical year, flows downstream. Note that the partial water budgets account for only human withdrawal and consumption of water and do not consider water consumed by other uses (such as, non-irrigated vegetation, and evaporation from bare soil or natural lakes).

Figure V-5 Gated-pipe, furrow irrigation in eastern Montana.

Figures V-6, V-7 and V-8 Water diverted and consumed by irrigated agriculture in the Upper, Middle and Lower Yellowstone River sub-basins, (includes estimated Wyoming uses) on an annual basis (based on Landsat analysis of year 2007).





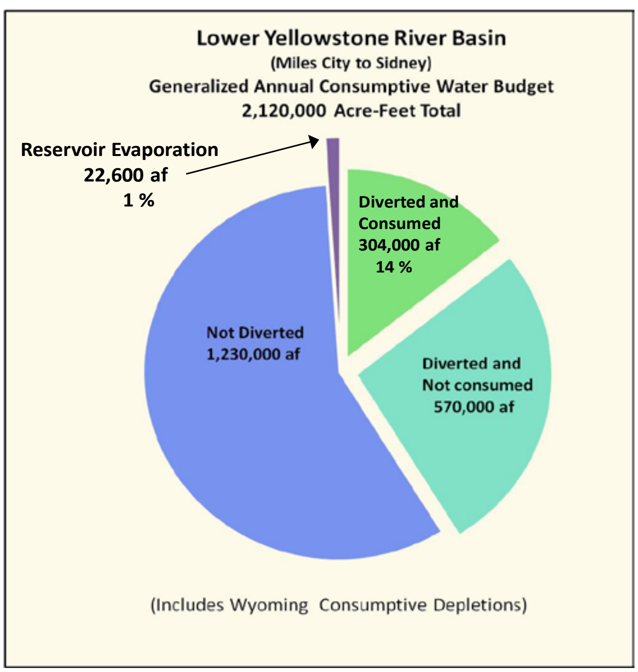


Figure V-9 Paradise Valley near Livingston Montana showing inlet channel to Livingston Ditch Diversion (center) and Depuy's Spring Creek (center right).

Water diverted and consumed for each of the planning sub-basins (Upper, Middle and Lower Yellowstone—see Figure IV-3 and Table IV-1 for sub-basin delineation and descriptions) are shown in Figures V-6 – V-8). As at the whole basin scale, irrigated agriculture is the largest diverter and consumer of water in each of the sub-basins; other uses (livestock, municipal and self-supplied domestic, and industrial) although not depicted in the figures (sub-basin scale), remain small percentages of diversions and consumptive uses.

LIVESTOCK WATER USE

Livestock production (Figure V-10) is an important use of water in the Yellowstone Basin and livestock watering is an essential consumptive use. Water sources typically include perennial streams where available and constructed stock ponds where necessary; many of the latter are served by small wells in the semi-arid eastern portions of the basin.

Figure V-10 Cattle grazing near Big Timber Montana.

INDUSTRIAL USE

More than 90 percent of water consumed for industrial purposes in Montana occurs within four Montana counties: Flathead, Missoula, Dawson, and Yellowstone. Statewide, industrial water consumption totals less than 10,500 acre-feet annually. Approximately 1,800 acre feet are used in the Yellowstone Basin. Major uses of industrial water in Montana are for oil and gas stimulation and recovery, processing of minerals, processing agricultural products, electrical power generation, and manufacturing.

Water use for hydraulic fracturing to stimulate oil production in horizontal wells is locally significant in the Williston Basin near the North Dakota border and potentially other areas including central Montana and the Rocky Mountain front. Water use for fracking and refracking has been reported in the range of 10 to 25 acre feet over the life of one well; however, actual use varies depending on many variables including geologic conditions and company operating practices. The Montana Board of Oil and Gas Conservation on-line database indicates that an average of 140 horizontal wells have been completed in Montana annually over the ten years ending in 2013 corresponding to potential annual water use from 1,400 acre feet to 3,500 acre feet. Both surface water and ground water are important sources for industrial water users.

There is potential for fracking in the middle Yellowstone sub-basin in both Montana (near Red Lodge) and Wyoming.

With the largest city in the state Billings, Yellowstone Basin has the highest municipal and industrial water use in the four MWSI planning basins.

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:

1. Colstrip (Rosebud County)
2. J E Corette Plant (Yellowstone County)
3. Hardin Generator Project (Big Horn County)

Figure V-11 Unit coal train carries coal from Colstrip area mines.

MUNICIPAL AND DOMESTIC WATER USE

Public Water Supply and Self Supplied Domestic

Public water supply and self-supplied domestic uses of water are a small but very important part of water use in the Yellowstone River Basin. Most Montana communities have (cities, towns, large subdivisions) a municipal water supply from surface or groundwater. Although there are over 350 permitted uses ranging from small well systems to the City of Billings, the cumulative total annual consumption is small, about 1.6 % of the total annual consumption of water in the Yellowstone Basin (see Figures VI-13 and VI-14; Figures VII-3 and VII-4).

Figure V-12 Miles City municipal water tower and swimming pool.

Summary of Water Withdrawals and Consumptive Use in Entire Yellowstone Basin (including Wyoming)

Annually, about 6 million acre-feet is estimated to be diverted from the Yellowstone River and tributaries for irrigation, stock, industrial, and municipal and domestic use (Figure V-13). The largest of the withdrawals is for irrigation, which accounts for about 97 percent of all diversions (5.8 million acre-feet). The remaining withdrawals are for industry (1.3 percent-76,100 acre-feet), municipalities (0.8 percent—48,000 acre-feet), self-supplied domestic (groundwater –0.6 percent—35,000 acre-feet) and stock watering (0.4 percent—22,600 acre-feet). (Wyoming water withdrawals are only included for irrigation and not the other more minor uses).

Figure V-13 Yellowstone River Basin average annual water diverted by use category.

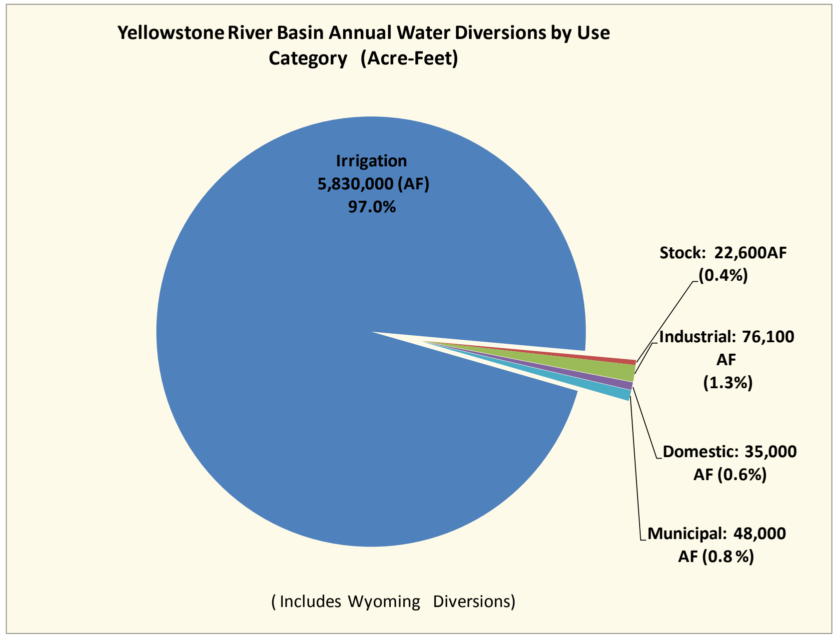
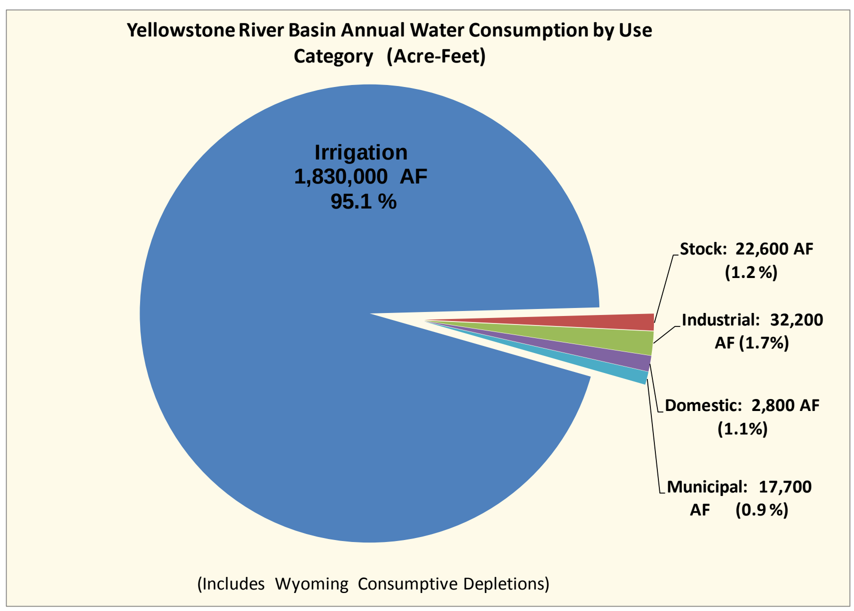


Figure V-14 Yellowstone River Basin average annual water consumed by use category.



Only a portion of the diverted water is consumed (Figure V-14). Annually, of the approximately 6 million acre-feet of water diverted, only about 1.9 million acre-feet of water is consumed by all uses of water. Of the total amount of water consumed, irrigation consumes 1.8 million acre-feet (95 percent), industry 32,000 acre-feet (1.7 percent), municipalities 18,000 acre-feet (0.9 percent), self-supplied domestic 2,800 acre-feet (1.1 percent) and stock watering 22,600 acre-feet (1.2 percent). Wyoming water consumption is only included for irrigation and industrial uses and not the other more minor consumptive uses).

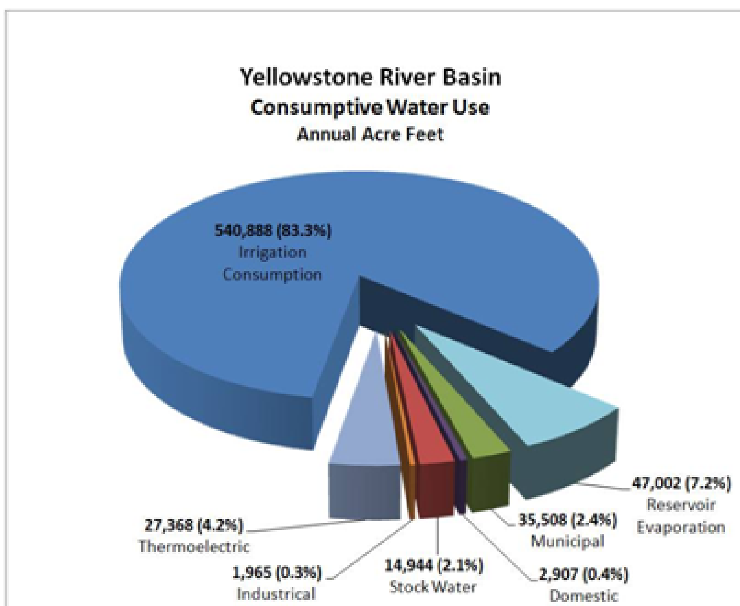
SUMMARY OF MONTANA (ONLY) CONSUMPTIVE WATER USES

Estimated annual consumptive use of water, for the Montana portion of the basin, is presented in Table V-1 and Figure V-15. Irrigation is the largest consumptive use of water (541,000 acre-feet per year) and is responsible for about 83 percent of the total water consumed. Reservoir evaporation is the next largest and consumes about 47,000 acre-feet per year (7 percent of the total). Water storage in reservoirs is an important component of water management in Montana and the Yellowstone Basin, helping to supply water during peak summer demand and provide water for recreation, hydropower and instream flow. But reservoirs lose a large amount of water to surface evaporation, a form of consumptive use.

Table V-1 Summary of Yellowstone River Basin (Montana Only) Total Consumptive Use

	Total Montana Basin Consumed (Acre-Feet)	Percent of Montana Basin Total Water Consumed
Irrigation	**541,000**	**83.3%**
Reservoir Evaporation	**47,000**	**7.2%**
Thermoelectric	**27,000**	**4.2%**
Municipal	**36,000**	**2.6%**
Livestock Watering	**15,000**	**2.2%**
Domestic	**2,900**	**0.4%**
Industrial	**2,000**	**0.3%**

Figure V-15 Estimated Total Annual Water Consumption in the Montana Portion of the Yellowstone River Basin.



Inventory of Non-Consumptive Water Use in the Yellowstone River Basin

Non-consumptive uses of water are very important uses of water in the Yellowstone River Basin and include water rights and DNRC Water Reservations, as well as federal reserved water rights. These allocations of water are primarily for maintenance of water in river channels (instream flows) to protect and enhance aquatic life (fish, aquatic biota, and wildlife), preserve dilution capacity for maintenance of water quality, and to recognize the importance of water as a tribal spiritual value.

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 12 blue ribbon trout streams for fish and wildlife habitat. These rights have a December 1970 priority date and provide instream flow protection against additional consumptive water use for the Yellowstone River in Stillwater, Sweetgrass and Park Counties from the North-South Carbon Stillwater County lines to where it leaves Yellowstone National Park boundary.

DNRC WATER RESERVATIONS

In 1979, the Yellowstone River Reservations process reserved FWP instream flow rights for a large number of streams in the Yellowstone Basin. These reservations vary by month, generally following seasonal flow patterns (see section of Plan on Water Reservations). Montana FWP manages an instream flow right of 5.5 million acre feet for the Yellowstone River at Sidney (Figure V-16).

Figure V-16 Comparison of FWP's instream flow reservations with 1911-2008 and 1999-2008 median streamflow for the Yellowstone River at Sidney (Brummond, 2003).

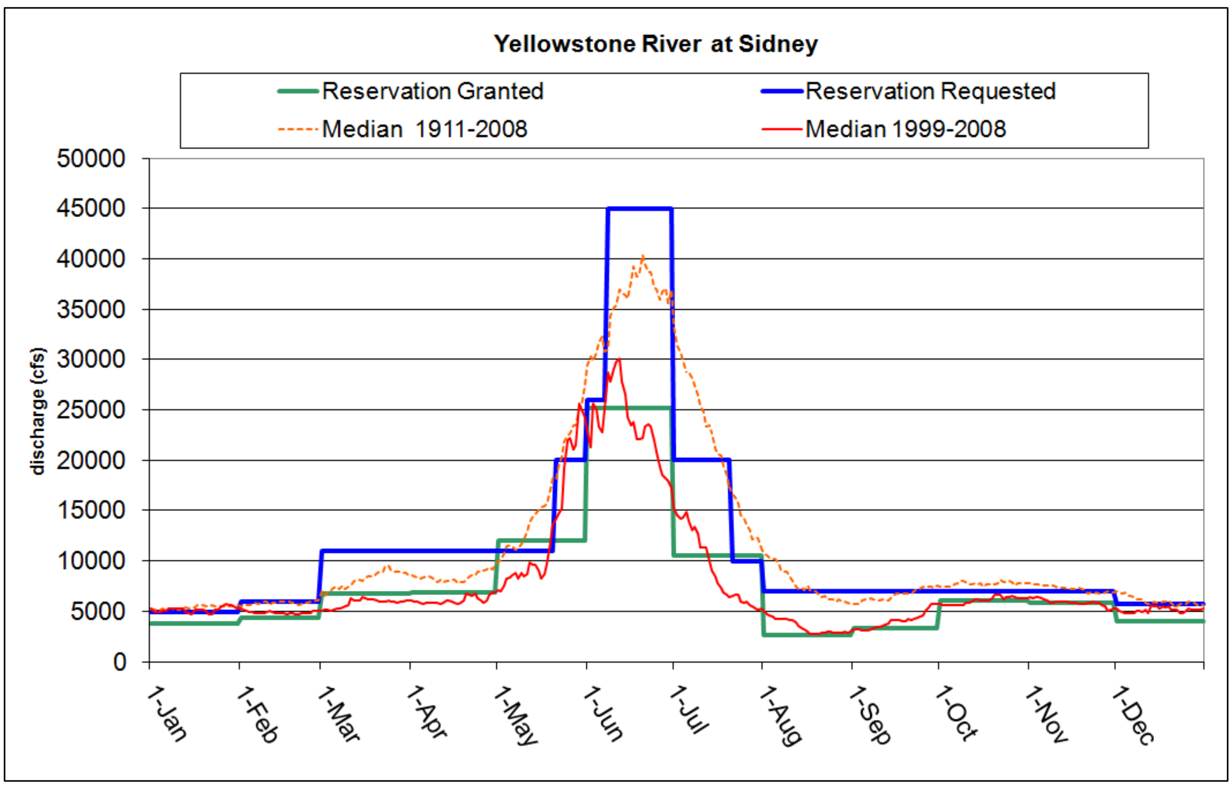


Figure V-17 Fly-fishing is an important recreational use of water in the upper and middle planning sub-basins.

United States Bureau of Land Management
The U.S. Bureau of Land Management reserved water for minor expansion of irrigated acreage on their land and to maintain riparian habitat, livestock and wildlife uses.

Montana Department of Environmental Quality
The Montana Department of Environmental Quality (DEQ) reserved instream flows to maintain water quality on the upper Missouri and Yellowstone Rivers. For the Yellowstone River, the DEQ reservations are for the 80th percentile of monthly flows less depletions from other reservations evaluated at Livingston, Billings, Miles City, and Sidney. The DEQ reservations run concurrently with the FWP instream flow reservations.

United States National Park Service Water Compacts
A compact between Montana and the National Park Service executed on January 31, 1994 established instream flow rights associated with Yellowstone and Glacier National Parks, Big Hole Battlefield, Little Bighorn Battlefield National Monument, and Bighorn Canyon National Recreation Area. These instream flow rights are tailored to the unique character of these areas, but typically include instream flows on streams where they flow within or form the boundary to Park Service lands. The compact allows for a certain level of consumptive use to which the United States agrees to subordinate its reserved instream flow water right.

Lakes and Reservoirs

Montana and Wyoming watersheds contain a variety of types of surface water storage projects, ranging from small impoundments (for example, stock watering and fish ponds), to large multi-purpose dams and reservoirs that provide flood control; water storage for irrigation, municipal, and industrial use; recreation and generation of hydropower. Larger projects typically have a federal partner—for example, Yellowtail Dam and Bighorn Lake are operated by the U.S. Bureau of Reclamation (USBR) in cooperation with both adjoining states. The state of Montana oversees operation of several state water projects constructed between 1930 and 1950 (Figure V-19). These projects are less than 100,000 acre-feet in size and constructed primarily for irrigation water supply although many are also used for recreation. Many of the aging projects are in need of maintenance and repair to meet dam safety standards.

Total storage in the Yellowstone River Basin is about 3,450,000 acre-feet (Montana 1,446,400 acre-feet and Wyoming 2,010,000 acre-feet). Yellowtail Dam and Bighorn Lake, which extends into Wyoming, account for most of Montana's storage (1,300,000 acre-feet) capacity (Figures V-18 and V-20 and Table V-2). With the exception of the Tongue River Dam, most of the larger storage projects are located in the western headwaters of the basin, and most of the storage capacity is developed in the Bighorn Basin (2,791,440 acre-feet).

Information on the major water storage projects is provided in Appendix F, Section V Non-consumptive Use. .

Figure V-18
U.S. Bureau of Reclamation's Yellowtail Dam and Bighorn Lake on the Bighorn River.

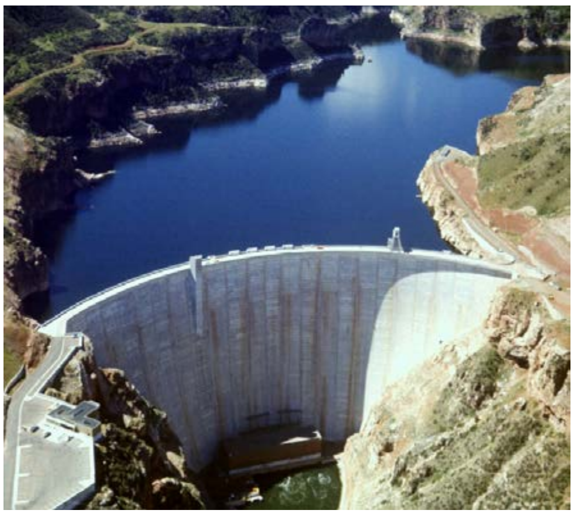


Figure V-19
Proposed, ongoing or recently completed water storage projects in Montana.

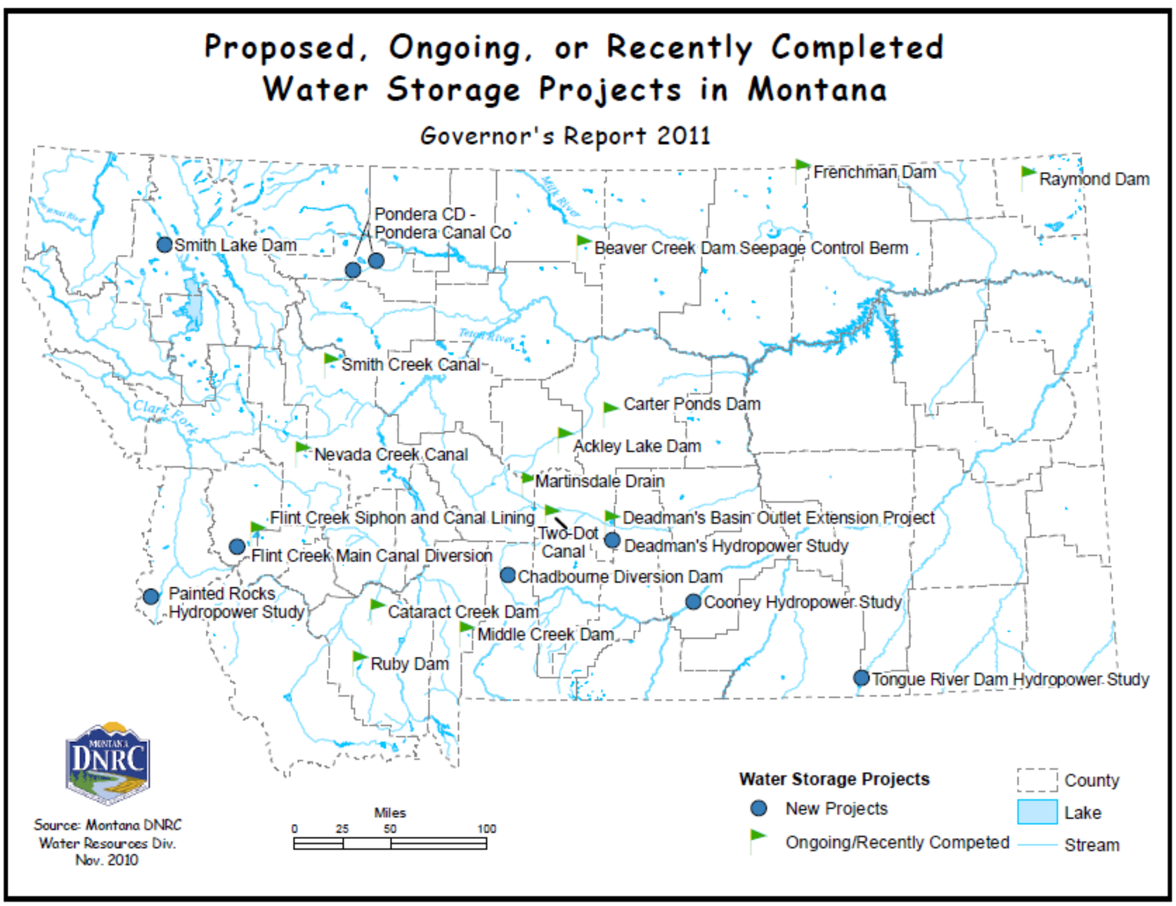
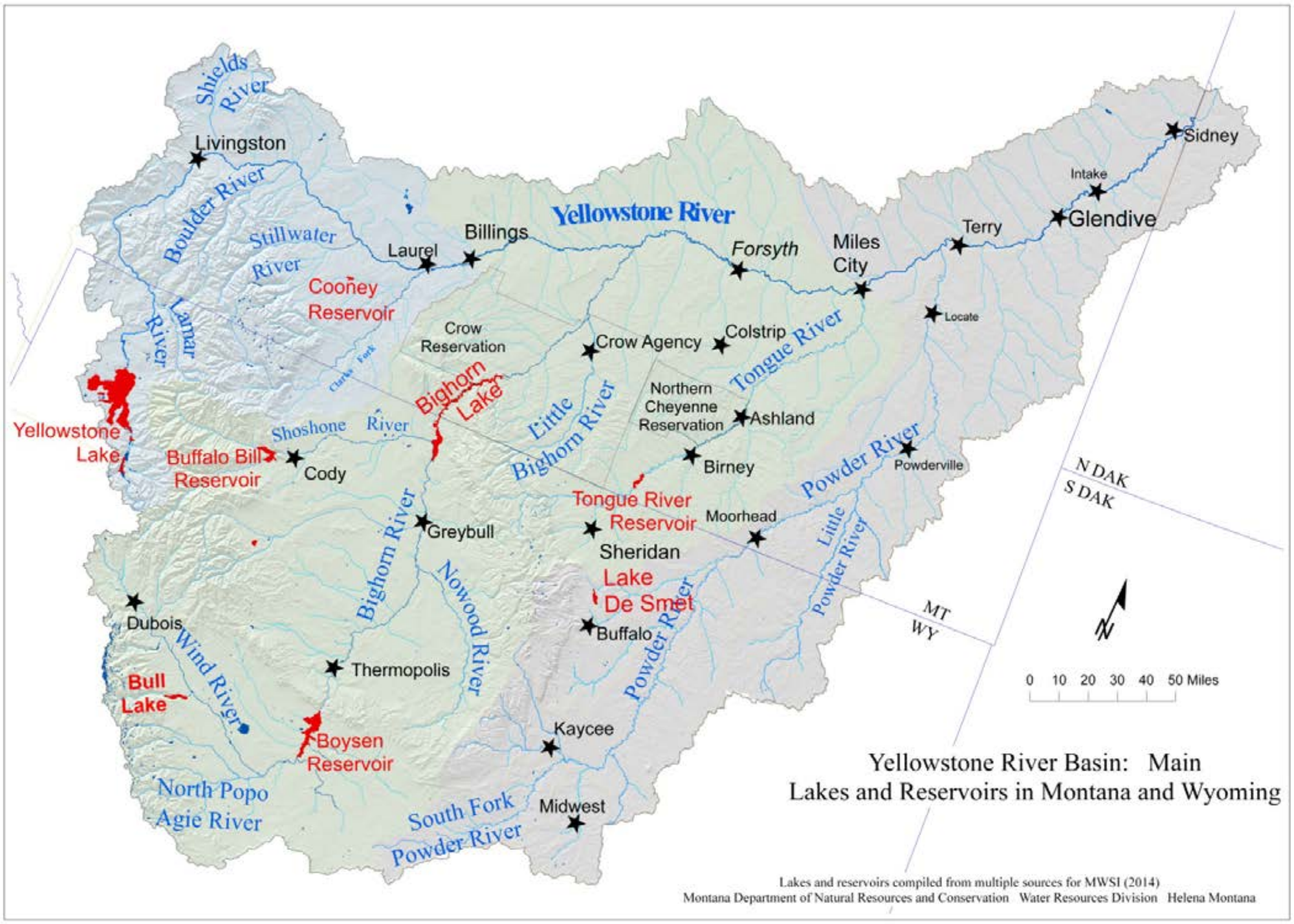


Table V-2 Yellowstone River Basin Lakes and Reservoirs with Capacity Greater Than 1000 Acre-Feet

Lake or Reservoir	MT	WY
	Clarks Fork Yellowstone River Basin	
Cooney Reservoir	28,230	
Glacier Lake	4,200	
	Bighorn River Basin	
(Lake) Adelaide Reservoir		4,770
Anchor Reservoir		17,410
Bighorn Lake	1,312,000	
Boysen Reservoir		757,900
Buffalo Bill Reservoir		644,500
Bull Lake		77,040
Greybull Valley Reservoir		9,390
Pilot Butte Reservoir		34,600
Sunshine Reservoir		52,990
Lower Sunshine Reservoir		58,750
Christina Reservoir		3,860
Corral Reservoir		1,030
Diamond Creek Dike Reservoir		18,380
Enterprise Reservoir		1,700
Fairview Extension Reservoir		1,410
Harrington Reservoir		1,200
Lake Cameahwait Reservoir		6,680
Lake Creek Reservoir		1,370
Newton Lakes		4,520
Perkins and Kinney Reservoir		1,200
Sage Creek Reservoir		2,780
Shell Reservoir		1,950
Shoshone Lake Reservoir		9,740
Teapot Reservoir		1,580
Tensleep Reservoir		3,510
Wiley Reservoir		1,020
Worthen Meadow Reservoir		1,500
	Powder River Basin	
Cloud Peak Reservoir		3,570
Dull Knife Reservoir		4,350
Healy Reservoir		5,140
Kearney Reservoir		6,320
Lake DeSmet		235,000
Muddy Guard Reservoir		2,340
Tie Hack Reservoir		2,440
Willow Park Reservoir		4,460
Posy No.1 Reservoir		1,540
	Tongue River Basin	
Bighorn Reservoir		4,630
Dome Reservoir		2,030
Park Reservoir		10,360
Sawmill Lakes Reservoir		1,280
Tongue River Reservoir	79,070	
Twin Lakes Reservoir		3,400
Willow Creek Reservoir	22,900	
	1,446,400	2,007,640

Figure V-20 Main lakes and reservoirs in the Yellowstone River Basin.



Tongue River Dam and Reservoir

Tongue River Dam and Reservoir (Figure V-21) are located on the Tongue River in Big Horn County, approximately five miles north of Decker. The project is owned by DNRC, and is managed jointly by the State Water Projects Bureau (within DNRC) and the Tongue River Water Users Association. Original construction began in 1938, and was completed in 1940 by the State Water Conservation Board, with a capacity of approximately 68,000 acre-feet.

Figure V-21 Tongue River Dam and Reservoir after dam and spillway rehabilitation.

In 1978, a flood discharging less than 10 percent of the rated spillway capacity did significant damage to the spillway. Rehabilitation included raising the dam crest an additional 4 feet, providing approximately 13,000 additional acre-feet of storage, and a normal, full-pool capacity of approximately 79,000 acre-feet; the surface area at full pool is approximately 3,700 acres.

HYDROPOWER

The Yellowstone Planning Basin's contains two hydroelectric facilities of significant size. The U.S. Bureau of Reclamation's Yellowtail Dam on the Big Horn River has a storage capacity of 1,381,189 acre-feet with a generation capacity of 250 megawatts. Hydroelectric power generation uses almost 2.7 million acre feet at Yellowtail Dam. Montana operates Mystic Lake Dam a two-unit hydroelectric plant on the West Rosebud Creek in the Beartooth Mountains with a generating capacity of 12 megawatts. The reservoir behind the dam has a storage capacity of 21,000 acre feet.

VI. Water Administration

Institutional and Legal Framework for Water Use in Montana

PRIOR APPROPRIATION AND THE MONTANA WATER USE ACT

In order to legally put water to a beneficial use in Montana, a person must have a water right. The elements of a Montana 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.
2. Doctrine of Prior Appropriation (first in time, first in right).
3. "Use it or lose it." A water right holder must use the water or risk losing the right to it.
4. The water diverted must be for a beneficial use, and all beneficial uses are equal under the law.
5. A water right is a property right and can be separated from the land.

6. 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.
7. 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.

The Act authorized the DNRC, the Montana Water Court and the district courts to fulfill different roles in execution of the charges of both the Act and the Montana Constitution:

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) –

- Negotiates settlements with federal agencies and Indian tribes claiming federal reserved water rights within the State of Montana; and
- 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. Two interim legislative committees provide oversight of water-related issues:

- *Water Policy Interim Committee (WPIC)* – permanent, joint bipartisan committee that studies water issues in order to develop policy direction and 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.

In addition to state agencies, numerous federal agencies have responsibility for water management in Montana:

Department of Agriculture
Farm Service Agency – administers cost share programs for farmers that improve water quality, soil stabilization, and irrigation systems. http://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 forest boundaries. http://www.usfs.gov

Department of Defense
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. http://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. http://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 electrical transmission systems. http://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. http://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. http://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. http://www.hud.gov

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

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

U.S. Geological Survey – researches the source, quantity, distribution, movement, and availability of surface and groundwater for national water data network and technical reports. http://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. http://www.epa.gov

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

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 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 decrees, public notices, 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 for all basins is 2028.

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. As of September 2014, active negotiations are occurring between the State of Montana, the Confederated Salish and Kootenai

Tribes (CSKT), and the United States. The parties hope to present a new compact to Montana's 2015 Legislature. A negotiated compact with is awaiting approval by the Montana Legislature. If this does not occur, or if the legislature does approve a CSKT–Montana compact, the Tribes must file their claims with the Water Court prior to July 1, 2015.

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 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 existing 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.

Exceptions to the general permitting requirements have to do with the amount of water being used. Small livestock reservoirs or pits holding less than 15 acre-feet of water and located on non-perennial streams may be constructed first and applied for within 60 days of completion. A permit will then be issued. Also, no permit is required to develop a well or spring producing 35 gallons per minute (or 10-acre-feet per year) or less; however, a notice of completion must be filed on these wells to establish a water right.

Large new appropriations have to meet more stringent approval requirements. Groundwater appropriations of more than 3,000 acre-feet per year, except for municipal or other public water supplies or for irrigation of cropland owned and operated by the applicant, must be approved by the Legislature. Applications to appropriate 4,000 acre-feet a year and 5.5 cubic feet per second or more assume a higher burden of proof and, in addition to being a beneficial use, must be a "reasonable" use, subject to more stringent criteria.

It is also possible to change a water right to a new or different use and transfer it to another person. Changes in water rights must be approved by DNRC, with that approval dependent on the applicant proving that criteria similar to those for a new appropriation will be met. Except for very large new appropriations or changes, those criteria do not include a consideration of water quality effects.

Public entities, such as DEQ, can apply for water reservations for future uses, including maintaining a minimum instream flow for water quality dilution purposes. Such water reservations have priority as of the date a correct and complete application is received, unless special legislative provisions apply. Instream flow reservations are also subject to a statutory limit of one-half the average annual stream flow on gauged streams such as the Yellowstone River.

YELLOWSTONE BASIN ADJUDICATION STATUS

The first final decrees in Montana’s adjudication process were issued by the Montana Water Court in 1983 in the Powder River basin. Since then, adjudication in the Yellowstone has proceeded with each of the 27 water right basins currently at various stages in the process (see Figure VI-1 and Table VI-1). All but one has either a final decree, preliminary decree, or a temporary preliminary decree. The remaining basin (Basin 43P - Bighorn River below Greybull River) is currently under examination. This means issue remarks are still being reconciled.

Temporary preliminary decrees are issued in basins containing federal reserved water rights where a compact has not been concluded. Such decrees contain all rights other than the reserved rights being negotiated. In these basins, a preliminary decree will be issued as a second stage and will include all rights in the temporary preliminary decree along with all the reserved water right compacts in the basin. In the Yellowstone basins these compacts include the Crow, Northern Cheyenne, USFS, Fort Keogh Agricultural Research Laboratory and the National Park Service. As shown in Table VI-1, once adjudication is complete, nearly 96,000 water rights will become legally enforceable. Combined with the 3,800 water rights currently under historic district court decrees, the Yellowstone Basin will have approximately 100,000 water rights eligible for enforcement.

Figure VI-1 Yellowstone Basin Adjudication Status Map.

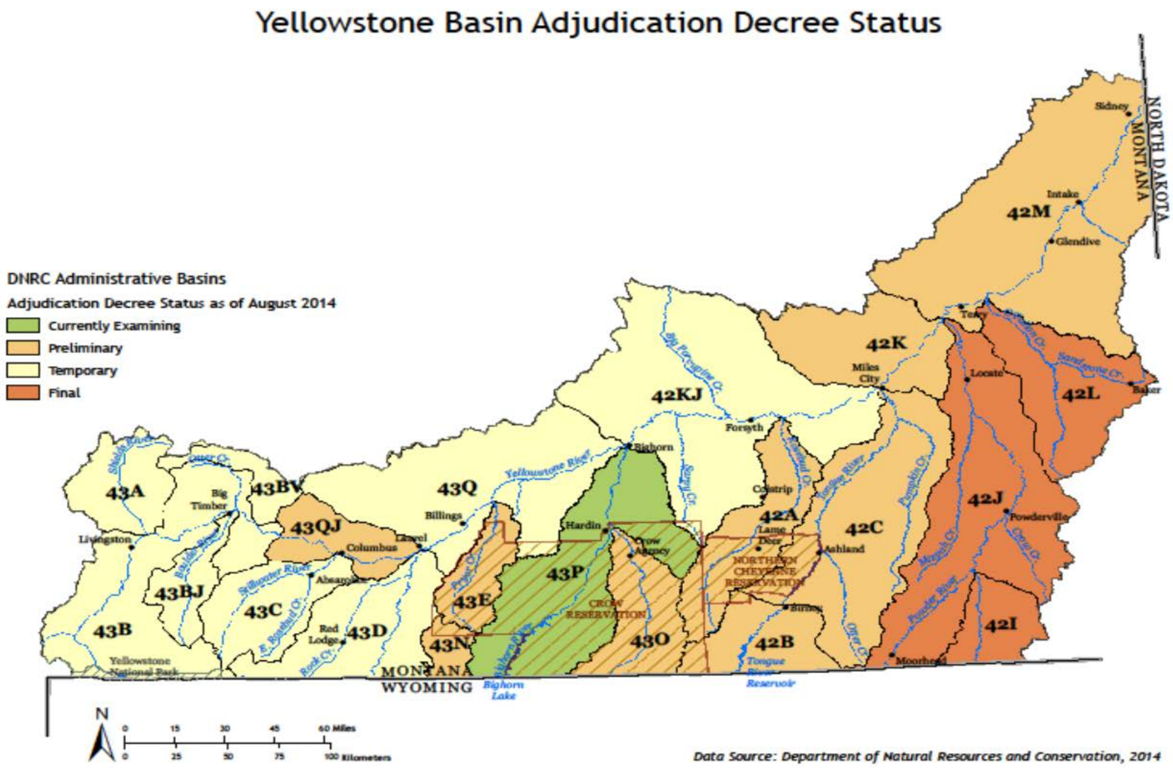


Table VI-1 Yellowstone Adjudication Status showing basin decrees, district court decrees and number of pre- and post-1973 claims.

BASIN	DECREE	DECREE DATE	Number of Pre-1973 Claims	Number of Post-1973 Claims	Number of water rights included in historic decrees
BELLE FOURCHE RIVER, ABOVE CHEYENNE RIVER	FINL	3/27/1984	210	27	0
BOXELDER CREEK	TEMP	2/1/1985	2451	493	0
LITTLE MISSOURI RIVER, ABOVE LITTLE BEAVER CREEK	TEMP	2/1/1985	2956	497	1
LITTLE BEAVER CREEK	TEMP	1/31/1985	976	309	0
BEAVER CREEK, TRIBUTARY TO LITTLE MISSOURI RIVER	PRLM	1/31/1985	706	397	0
LITTLE MISSOURI, BELOW LITTLE BEAVER CREEK	FINL	3/27/1984	203	29	0
ROSEBUD CREEK	PRLM	5/23/2013	1220	317	1
TONGUE RIVER, ABOVE & INCLUDING HANGING WOMAN CREEK	PRLM	2/28/2008	1349	397	18
TONGUE RIVER, BELOW HANGING WOMAN CREEK	PRLM	2/28/2008	4712	1276	18
LITTLE POWDER RIVER	FINL	5/31/1983	2273	427	6
POWDER RIVER, BELOW CLEAR CREEK	FINL	5/31/1983	8855	1617	28
YELLOWSTONE RIVER, BETWEEN TONGUE & POWDER RIVERS	PRLM	9/19/1985	1467	792	1
YELLOWSTONE RIVER, BETWEEN BIGHORN & TONGUE RIVERS	TEMP	11/14/2003	4808	1587	10
O'FALLON CREEK	FINL	4/17/1985	2751	850	0
YELLOWSTONE RIVER, BELOW POWDER RIVER	PRLM	1/24/2014	5290	3610	4
SHIELDS RIVER	TEMP	8/3/1988	3299	952	1176
YELLOWSTONE RIVER, ABOVE & INCLUDING BRIDGER CREEK	TEMP	1/16/1985	4884	3729	1317
BOULDER RIVER, TRIBUTARY TO YELLOWSTONE RIVER	TEMP	4/3/1985	817	459	43
SWEET GRASS CREEK	TEMP	12/19/1984	714	197	242
STILLWATER RIVER	TEMP	11/7/1985	1720	1752	58
CLARKS FORK YELLOWSTONE RIVER	TEMP	6/9/1993	2613	3303	829
PRYOR CREEK	PRLM	2/25/2010	631	250	0
SHOSHONE RIVER	PRLM	6/13/2013	165	63	19
LITTLE BIGHORN RIVER	PRLM	3/25/2010	1177	195	8
BIGHORN RIVER, BELOW GREYBULL RIVER			2111	724	17
YELLOWSTONE RIVER, BETWEEN CLARKS FORK YELLOWSTONE & BIGHORN RIVER	TEMP	12/29/1998	2480	7781	21
YELLOWSTONE RIVER, FROM BRIDGER CREEK TO CLARKS FORK YELLOWTONE	PRLM	7/23/1985	1071	1869	1
TOTAL			61909	33899	3818

Yellowstone Water Reservations

The first order to establish water reservations on any river in Montana was issued in December 1978 by DNRC. This order reserved water in the Yellowstone River Basin for municipal use, irrigation, off-stream storage, and instream flow. Tables VI-2 through VI-6 lists these reservations known collectively as the Yellowstone Water Reservations. An annual total of 716,237 acre-feet was reserved for future consumption by Montana irrigators and municipalities in the basin. The largest instream flow reservation was granted by the Board of Natural Resources to the Department of Fish, Wildlife and Parks for 5,578,890 acre-feet per year at Miles City. The reservations have a significant effect on the amount of water that can be appropriated through-out the Yellowstone River Basin.

PURPOSE AND NEED

In the years prior to 1974, a substantial number of applications for water use permits for drawing large amounts of water from the Yellowstone River were received by the DNRC. Many of these applications requested significant amounts of water for energy-related industrial development. Reacting to concerns that industrial water development would impair municipal, agricultural, and instream water use, the Montana Legislature passed the Water Moratorium Act of 1974, which suspended all applications for water use permits for diversions larger than 20 cfs or storage over 14,000 acre-feet in the Yellowstone Basin until March 10, 1977. During this period, the state determined the amount of water available for allocation and quantified instream flow requirements for the Yellowstone River and its tributaries. The moratorium also allowed local, state and federal agencies to assess their future water requirement and submit applications for the reservation of water.

HISTORY

The moratorium on new appropriations encouraged applicants to submit applications for reservations before November 1, 1976. Between 1973 and 1976, DNRC prepared an environmental impact statement that analyzed the effects the water reservations and increased water use would have on the basin’s hydrology, geomorphology, water quality, wildlife, existing uses, recreation, and economics (DNRC final EIS, 1976). The moratorium was extended for one year in order for federal agencies to apply for off-stream storage reservations and to allow DNRC enough time to gather and analyze the data necessary for decisions on the granting of reservations.

By November 1, 1976, 30 applications for water reservations were filed with DNRC for Yellowstone River water. A total of 1,181,559 acre-feet per year was requested for irrigation. This total included thirteen requests from conservation districts, two from irrigation districts, and three from the Montana Department of State Lands. Table VI-2 shows the conservation district water reservation balance as of December 31, 2013. Eight municipalities filed applications totaling 391,500 acre-feet per year for domestic and municipal use. Two reservations, for a total of 1,600,000 acre-feet per year for multipurpose reservoir storage, were filed on the Tongue and Powder rivers by DNRC. In addition, the U.S. Bureau of Reclamation filed for a reservation totaling 729,500 acre-feet per year for three potential off-stream storage reservoirs on the Yellowstone River between Billings and Miles City.

Requests for major non-consumptive reservations of instream flow, the maximum being 8,206,723 acre-feet per year at Sidney, were filed by the Montana Departments of Health and Environmental Sciences (now DEQ), and Fish, Wildlife and Parks. All of the applications filed by conservation districts mentioned instream flows, although only the North Custer Conservation District’s application mentioned a specific figure.

Table VI-2 Yellowstone Conservation District Water Reservation Balance

CONSERVATION DISTRICT	SOURCE OF WATER SUPPLY	NO. PROJECTS APPROVED	VOLUME GRANTED (AF)	VOLUME ALLOCATED (AF)	REMAINING VOLUME (AF)	% VOLUME ALLOCATED	FLOW GRANTED (CFS)	FLOW ALLOCATED (CFS)	REMAINING FLOW (CFS)
YELLOWSTONE RIVER BASIN CONSERVATION DISTRICT WATER RESERVATION BALANCE as of December 31, 2013									
UPPER BASIN									
BIG HORN	Big Horn River	29	20,185	12,925	7,260	64.03%	144	127	17
CARBON	Yellowstone River & tribs, Clarks Fork of Yellowstone	5	22,676	1,424	21,252	6.28%	131	11	120
PARK	Yellowstone River	6	64,125	1,586	62,539	2.47%	446	12	434
STILLWATER	Yellowstone River & tribs, Stillwater River	9	16,755	1,018	15,737	6.07%	122	14	108
SWEET GRASS	Yellowstone River, Southern Tributaries	9	46,245	5,734	40,512	12.40%	363	53	310
YELLOWSTONE	Yellowstone River	15	57,963	5,999	51,964	10.35%	378	60	318
Upper Basin Subtotal		**73**	**227,949**	**28,685**	**199,264**	**12.58%**	**1,584**	**277**	**1,307**
LOWER BASIN									
CUSTER	Yellowstone River, Powder River & tribs	18	28,478	11,045	17,433	38.78%	N/A	N/A	N/A
DAWSON	Yellowstone River	14	45,855	5,525	40,330	12.05%	331	45	286
LITTLE BEAVER	O'Fallon Creek & tribs, Cabin Creek & tribs, Pennel Creek & tribs	39	12,773	1,322	11,451	10.35%	N/A	N/A	N/A
PRAIRIE	Yellowstone River, Powder River	10	68,467	5,711	62,756	8.34%	553	46	513
POWDER RIVER	Powder River	27	13,680	8,123	5,558	59.38%	N/A	N/A	N/A
RICHLAND	Yellowstone River	9	45,620	28,853	16,767	63.25%	354	167	187
ROSEBUD	Yellowstone River	14	87,003	3,754	83,249	4.31%	541	75	466
TREASURE	Yellowstone River, Bighorn River	5	18,361	1,842	16,519	10.03%	119	25	94
Lower Basin Subtotal		**136**	**320,237**	**66,175**	**254,063**	**20.66%**	**1,897**	**357**	**1,547**
Total Yellowstone		**209**	**548,186**	**94,860**	**453,326**	**17.30%**	**3,481**	**634**	**2,854**

Table VI-3 Municipal Reservations	
Town	Annual Reservation (acre-feet)
Livingston	4,510
Big Timber	365
Columbus	883
Laurel	7,151
Billings	41,229
Miles City	2,889
Glendive	3,281
Broadus	605
TOTAL	60,913

Table VI-4 Multipurpose/Storage Reservations from the Yellowstone River		
Applicant	Reservoir	Annual Reservation (acre-feet)
DNRC	Tongue River	383,000
USBR	Cedar Ridge	121,800
	Buffalo Creek	68,000
	Sunday Creek	539,000
TOTAL		1,111,800

Table VI-5 Instream Flow Reservations on the Yellowstone River	
Location	Annual Reservation (acre-feet)
Yellowstone River at Livingston	1,879,013
Shields River near Clyde Park	35,434
Shields River at Wilsall	21,764
Big Timber Creek	28,267
West Boulder River	74,853
East Boulder River at mouth	23,146
Boulder River at Contact	137,120
Boulder River at Big Timber	195,163
Stillwater River at mouth	379,795
Yellowstone River at Billings	3,679,968
Bighorn River at mouth	2,477,987
Yellowstone River at Miles City	5,578,892
Tongue River at Wyoming state line	244,799
Tongue River at mouth	54,289
Powder River at mouth	95,201
Yellowstone River at Sidney	5,429,310

Table VI-6 Irrigation Reservations

Reservation Holder	Annual Reservation (acre feet)	Maximum Diversion (cfs
Park Co. Conservation District (CD)	64,125	445.9
Sweet Grass Co. CD	46,245	363.4
Stillwater Co. CD	16,755	122.1
Carbon Co. CD	22,676	130.7
Yellowstone Co. CD	57,963	378.2
Bighorn Co. CD	21,239	143.8
Treasure Co. CD	18,361	118.6
Rosebud Co. CD	94,147	540.7
North Custer Co. CD	39,375	---
Powder River Co. CD	13,680	---
Prairie Co. CD	68,467	552.7
Dawson Co. CD	45,855	330.8
Richland Co. CD	45,620	354.2
Little Beaver CD	12,773	---
Buffalo Rapids Project	11,997	16.55
Montana Dept. of State Lands (No.9931-r)	14,679	86.11
Montana Dept. of State Lands (No.9933-r)	25,889	185.2
Montana Dept. of State Lands (No.9934-r)	15,078	---
US-BLM	2,924	12.287
US-BLM	17,476	75.76
TOTAL	655,324	

In addition to establishing amounts of water associated with each application, the Board of Natural Resources also established priorities for the use of the water. Municipal use has first priority. Upstream from the mouth of the Bighorn River, instream use has second priority and agriculture third. Below the confluence of the Bighorn and the North Dakota border, agriculture has second priority and instream flow third. Storage reservations have the lowest priority.

Since the reservations were granted two changes have been authorized. The first, authorized in September 1980, increased the reservation for the City of Billings from 41,229 acre-feet per year, with an average diversionary flow rate of 56.9 cfs, to 53,500 acre-feet, with an average diversionary flow rate of 74.0 cfs. The second change, authorized in November 1980, was a result of a decrease in the instream reservation of the Yellowstone River above the mouth of the Bighorn River (as measured at Billings) held by the Department of Fish, Wildlife and Parks and the Department of Health and Environmental Sciences (now DEQ). The original reservation was established on the basis of the 65^{th} percentile flow, which means that flows in excess of the reservation could be expected in 65 out of 100 years. The change reduced this reservation from the 65^{th} to the approximately 83^{rd} percentile. This change increased the amount of water available for the irrigation reservations.

EFFECTS OF RESERVATIONS ON SENIOR WATER RIGHTS

The Yellowstone Water Reservations were made with the stipulation that all senior water rights must be met first. Currently, these senior rights are being quantified through the water right adjudication process.

Federal and Tribal Reserved Water in the Yellowstone Basin

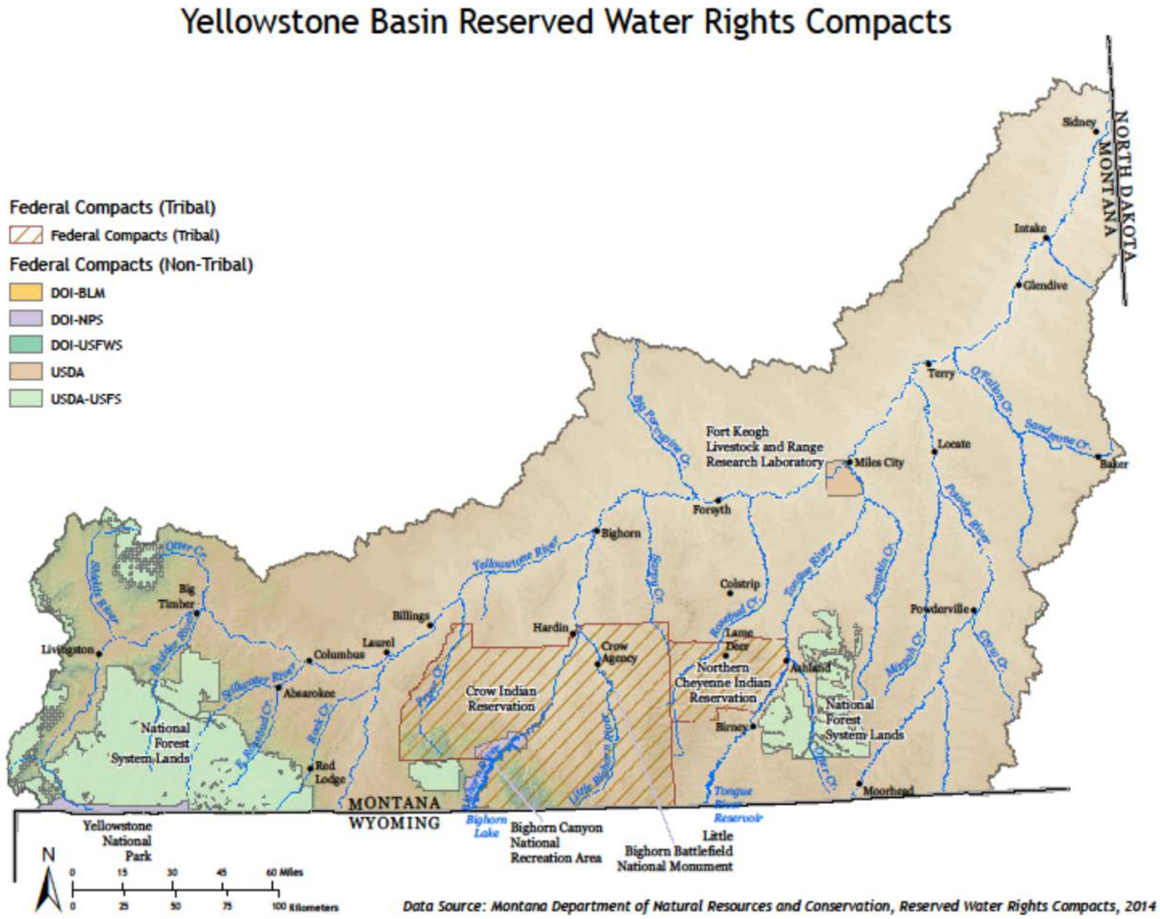
The right to use water on federal and tribal reservations of land within Montana are known as federal or tribal reserved water rights, or *Winters* rights, named for the U.S. Supreme Court case that established the existence of these rights in 1908. The landmark *Winters v. United States* involved a dispute between the Fort Belknap Indian Community in north central Montana and upstream farmers on the Milk River. When farmers began diverting water upstream from the Fort Belknap Reservation, this diminished water supplies for agriculture on the Reservation. The dispute eventually made it to the U.S. Supreme Court. The Court sided with the Gros Ventre and Assiniboine Tribes, holding that the 1855 treaty establishing their Reservation had implicitly reserved an amount of water necessary to fulfill the purposes for which the Reservation was established. These reserved water rights are distinctly different from the water reservations granted to Conservation Districts and other public entities in the Yellowstone and Missouri Basins by the Legislature.

Although the principle of implied rights was originally established in the context of an Indian reservation, the rule of the case, known as the *Winters' Doctrine*, has since been applied to any federal reservation of land requiring water to accomplish the purpose of the reservation. The Doctrine holds that with the withdrawal of land from the public domain, whether by executive order, treaty, or Act of Congress, there is an implied reservation of water sufficient to accomplish the purpose(s) for which the land was reserved. Such rights have a *priority date* of the date the reservation was established. Because the amount of water reserved is determined by the purpose(s) of the reservation, these rights are not established or determined by beneficial use, as state-based rights are. In addition federal and tribal reserved water rights cannot be abandoned through non-use.

In Montana, reserved water right compacts have been ratified for 6 Indian reservations and 11 federal enclaves including national parks, forests, monuments, and wildlife refuges, and for federally designated wild and scenic rivers. Montana's Reserved Water Rights Compact Commission (Commission) was established by the Montana Legislature in 1979 as part of the state-wide general stream adjudication. The Commission is authorized to negotiate settlements with federal agencies and Indian tribes claiming federal reserved water rights within the State of Montana. The Commission includes nine members, each serving a four-year term. Two are appointed by the Speaker of the House, two by the President of the Senate, one by the Attorney General's office and four by the Governor's office. The Commission negotiates on behalf of the Governor's Office and represents the interests of State water users. A DNRC legal and technical staff supports implementation of existing compacts and the Commission.

Figure VI-2 shows the location of reserved water rights compacts in the Yellowstone Basin. The two tribal compacts are for the Crow and Northern Cheyenne Reserved Water. Other federal compacts in the Yellowstone Basin include the U.S. Forest Service, the National Park Service, and the U.S. Department of Agriculture's Fort Keogh Livestock and Range Research Laboratory near Miles City.

Figure VI-2 Federal or Tribal Reserved Water Rights Compacts in the Yellowstone River Basin.



CROW WATER RIGHTS COMPACT

The compact was ratified by the United States Congress in November 2010. The settlement package was approved by the Crow Tribe in a referendum election in March 2011. The Montana Water Court issued a preliminary decree for this compact in January 2013 (Case No. WC-2012-06). The Crow Compact recognizes water rights for the Crow Tribe in the following basins:

- Basin 42A, the main stem of Rosebud Creek and its tributaries from its headwaters to its confluence with the Yellowstone River;
- Basin 42B, the main stem of the Tongue River and its tributaries from the Montana-Wyoming border to above and including Hanging Woman Creek;
- Basin 42KJ, the main stem of the Yellowstone River and its tributaries between Bighorn River and Tongue River;
- Basin 43D, the main stem of the Clarks Fork Yellowstone River and its tributaries from the Montana-Wyoming border to its confluence with the Yellowstone River;
- Basin 43E, the main stem of Pryor Creek and its tributaries from its headwaters to its confluence with the Yellowstone River;
- Basin 43N, the main stem of the Shoshone River and its tributaries within Montana;
- Basin 43O, the main stem of the Little Bighorn River and its tributaries from the Montana-Wyoming border to its confluence with the Bighorn River;
- Basin 43P, the main stem of the Bighorn River, below Greybull River, and its tributaries (exclusive of the Little Bighorn River and its tributaries) within Montana to its confluence with the Yellowstone River; and
- Basin 43Q, the main stem of the Yellowstone River and its tributaries between Clarks Fork Yellowstone River and Bighorn River.

Article III of the Crow Compact provides the key water rights provisions:

1. The Tribe has a quantified water right of 500,000 acre feet per year (AFY) to the natural flow of the Bighorn River (Basin 43P) and its tributaries, and groundwater for tribal uses, with a Tribal priority date of May 7, 1868, but agrees to share shortages in natural flow with all water rights recognized under state law with a priority date before the June 22, 1999.
2. The Tribe is entitled to an allocation of 300,000 AFY of water stored in Bighorn Lake. Of the storage allocation, 150,000 AFY may be put to use in addition to the natural flow right (including 50,000 AFY that may be used outside the Reservation) and 150,000 AFY may be used only to supplement natural flow in times of natural flow shortage.
3. The Tribe has rights to all surface flow, groundwater and storage in the other eight basins on the Reservation (43O, 43E, 42A, 42B, 42KJ, 43D, 43N, 43Q) with a tribal priority date of May 7, 1868, but agrees to share shortages in natural flow with all water rights recognized under state law with a priority date before the June 22, 1999 ratification by the Montana Legislature of the Crow Compact.
4. The Tribe may use 47,000 AFY on the Ceded Strip with a tribal priority date of May 7, 1868, but agrees to share shortages in natural flow with all water rights recognized under state law with a priority date before the June 22, 1999 ratification by the Montana Legislature of the Crow Compact. Authorized uses include all current uses of the tribal water right and future uses as limited by the Compact.

5. The Tribe agrees that any future uses of the tribal water right cannot adversely affect valid state-based water rights and uses of the tribal water right in existence before June 22, 1999. All basins that include the tribal water right are closed to the issuance of new water rights permits under state law after June 22, 1999.

NORTHERN CHEYENNE WATER RIGHTS COMPACT

The Compact entered into by the State of Montana and the Northern Cheyenne tribe of the Northern Cheyenne Indian Reservation was ratified effective May 20, 1991. In general, the Northern Cheyenne Compact provides water as follows:

- **Existing Non-Agricultural Uses** - Tribal and individual Indian stockwater, domestic and municipal water uses on the Reservation and in existence as of the ratification date are recognized and protected as part of the Tribal Water Right,
- **Tongue River** - The Tribal Water Right in the Tongue River basin consists of the right to divert or use or to permit the diversion or use of up to 32,500 acre-feet per year, from a combination of direct flow, storage, and exchange water.
    - Direct Flow Right: The Tribe has a right to divert or use or permit the diversion or use of up to 12,500 acre-feet of water per year from direct flow of the Tongue River and its tributaries with a priority date of October 1, 1881; provided, that:
        - The Tribe's annual depletion of its direct flow water right in the Tongue River and its tributaries will not exceed 75 percent of the amount diverted, or 9,375 acre-feet per year; and
        - The Tribe's direct flow water right in the Tongue River and its tributaries may not be used in a manner that adversely affects:
            - Miles City Decree water rights, or
            - Water rights from off-Reservation tributaries of the Tongue River, with a priority date of June 30, 1973 or earlier and are based on the use of an irrigation system in place and not abandoned as of June 30, 1973.
    - Storage and Exchange Water. The Tribe has a right to divert or deplete, or permit the diversion or depletion of, up to 20,000 acre-feet per year from a combination of water stored in the Tongue River Reservoir and exchange water. The availability of the 20,000 acre-feet per year depends, as provided in the Tongue River Water Model, upon the annual schedule utilized by the Tribe for diversions of Tongue River direct flows.
- **Rosebud Creek**
    - Water Right. The Tribe has a right to divert or use or to permit the diversion or use from Rosebud Creek and its tributaries, for agricultural purposes only, of 1,800 acre-feet of water per year, or enough water to irrigate 600 acres of land per year, whichever is less, with a priority date of October 1, 1881.
    - Additional Water Right. The Tribe has a right to divert or use or permit the diversion or use from Rosebud Creek and its tributaries, for any purpose, of up to 19,530 acre-feet of water per year, or enough water to irrigate 6,510 acres of land per year, whichever is less, with a priority date of October 1, 1881.

- Moratorium on the issuance of permits in the Rosebud Creek basin concurrent with the ratification date of the Compact.

- **Groundwater**
  - Alluvial Groundwater. The Tribe has a right to withdraw and use, or permit the withdrawal and use of, alluvial groundwater in lieu of surface water diversions of the Tongue River and Rosebud Creek Tribal Water Right, subject to the same terms and conditions of this Compact that apply to such surface water diversions.
  - Non-alluvial Groundwater. Except where a Tribal right to non-alluvial groundwater is established pursuant to Article VII.B. of this Compact, Tribal use or authorization of use of non-alluvial groundwater will, at the election of the Tribe, comply with state law.
- **Stockwater Impoundments** - The Tribe may construct, or permit the construction of stockwater impoundments on the Reservation, where the capacity of the impoundment is less than 15 acre-feet
- **Subirrigation** - The Tribe is entitled to take advantage of any natural subirrigation occurring on the Reservation.
- **Big Horn Reservoir (Yellowtail) Storage** - Tribal Allocation. As a part of the Tribal Water Right, the Secretary of the Interior will allocate 30,000 acre-feet per year of stored water in Bighorn Reservoir

Administration

- Except as otherwise provided in this Compact, the use of the Tribal Water Right will be administered by the Tribe. Administration and enforcement of the Tribal Water Right will be pursuant to the Tribe's water code.
- Any use of the Tribal Water Right involving a point of diversion or place of use located off the Reservation will be considered an off-Reservation use; provided, that releases or diversions from Bighorn Reservoir or Tongue River Reservoir for use on the Reservation will not be considered off-Reservation uses.
- The State will administer all rights to the use of surface water and groundwater within the Reservation which are not a part of the Tribal Water Right.

Operation of Tongue River Reservoir

- To provide for Tongue River Reservoir operation procedures that are consistent with the purposes of this Compact, a reservoir operation plan will be developed by a five-member advisory committee. The committee will have representatives from the State of Montana, the Tongue River Water Users Association, the Northern Cheyenne Tribe, the United States, and a fifth member to be selected by the other four. The advisory committee will annually agree upon a reservoir operation schedule setting forth proposed uses of storage and direct flow for the year.

Establishment of The Northern Cheyenne - Montana Compact Board

- The Board will consist of three members: one member appointed by the Governor of the State of Montana; one member appointed by the Northern Cheyenne Tribal Council; and one member selected by the other two members.
- The Northern Cheyenne-Montana Compact Board will have jurisdiction to resolve controversies over the right to the use of water between users of the Tribal Water Right on the one hand and users of state water rights on the other hand.

FORT KEOGH COMPACT

The United States Department of Agriculture Fort Keogh Livestock and Range Research Laboratory - Montana Compact (Compact) recognizes federal reserved rights for the Fort Keogh Livestock and Range Research Laboratory located in Water Court Basins 42C and 42KJ near Miles City, Montana for existing and future irrigation, stock, and administrative uses and emergency fire suppression. The Compact quantifies federal reserved water rights for the Fort Keogh Livestock and Range Research Laboratory from the Yellowstone and Tongue Rivers and seeps, naturally-occurring surface flows and groundwater sources arising inside the boundaries of the Fort Keogh Livestock and Range Research Laboratory.

The Compact recognizes federal reserved water rights within the United States Fort Keogh Livestock and Range Research Laboratory lands:

- to withdraw or divert 58 cubic feet per second up to 6,092 acre feet from the Yellowstone River in Water Court Basin 42KJ for current irrigation use on 1,523 acres.
- to withdraw or divert by water spreading on Reservation Creek, a tributary of the Yellowstone River, in Water Court Basin 42KJ for current irrigation use on 450 acres.
- to withdraw or divert by water spreading on an unnamed tributary of the Tongue River in Water Court Basin 42C for current irrigation use on 203 acres.
- to withdraw or divert water up to a total additional flow of 23 cubic feet per second from the Yellowstone River, a tributary, or groundwater in Water Court Basin 42KJ for future irrigation use on an additional 620 acres.
- for consumptive use for stockwatering purposes from the sources, at the volumes and for use at the locations identified in Compact Appendix 5, provided that the total current Stock Use shall not exceed the historic maximum of 3,000 Animal Units (an Animal Unit is a cow-calf pair or other equivalent).
- in addition to the current Stock Use, for consumptive use for stockwatering purposes at the same locations and the same volume of water as described above for future stock use not to exceed an additional 2,000 Animal Units.
- for current administrative uses totaling 26.70 acre-feet per year.
- for future administrative uses up to a total additional volume of 18 acre-feet per year.

The priority date for these rights is April 15, 1924.

U.S. DEPT. OF AGRICULTURE, FOREST SERVICE COMPACT

Since 1992, the Montana Reserved Water Rights Compact Commission (RWRCC) and the United States Department of Agriculture, Forest Service (Forest Service) have been in active negotiations concerning federal reserved water rights on National Forest System lands in Montana. In general, the Compact recognizes reserved water rights for the Forest Service for administrative and emergency firefighting uses and instream flows. To resolve major differences between the negotiating parties concerning the existence, nature and extent of any possible reserved water rights for instream flows under federal law, the proposed Compact uses state law to create numerous state-based water rights for instream flow on National Forest System lands and to set up a process for applying for additional instream flows under state law. Below is a summary of what the Compact does. The Yellowstone River Basin in Montana comprises portions of the Custer Gallatin National Forest.

- Federal Reserved Water Rights - 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. Priority date is date of the creation of the National Forest or as specified.

1. Instream Flows under State Law -
    - Creates, in the Compact, 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. All of these water rights will have a priority date of 2007.
    - Establishes 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. 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.

- Continues the ability of the Forest Service to object in the Water Court to any water right claim on or crossing National Forest System lands that adversely affects Forest Service interests.
- Coordinates state and federal permitting processes.
- Allows a change of use from an appropriation to divert or withdraw water on land owned by the Forest Service above or immediately adjacent to the National Forest boundary to an instream flow. This is primarily intended to allow the Forest Service to change irrigation and other rights to instream flow on land that it might acquire in the future.

YELLOWSTONE RIVER COMPACT

This compact divides unused and unappropriated waters of the interstate tributaries (Clarks Fork of the Yellowstone River, Tongue River, Powder River and Bighorn River) of the Yellowstone River as of January 1, 1950, between Wyoming and Montana. According to the compact, Wyoming and Montana are entitled to the following percentages of *surplus flow* after January 1, 1950 as shown in Table VI-7:

Table VI-7 Percent of surplus flow allocated to Montana and Wyoming by the Yellowstone River Compact

Tributary	Wyoming (percent)	Montana (percent)
Clarks Fork	60	40
Bighorn	80	20
Tongue	40	60
Powder	42	58

Surplus flow is determined on an annual water year basis measured from October 1 of any year through September 30 of the following year. The quantity of water to which the percentage factors (shown in Table VI-7 above) shall be applied through a given date in any water year shall be, in acre-feet, equal to the algebraic sum of:

- The total diversion of irrigation, municipal, and industrial uses developed after January 1, 1950, and above the point of measurement during the period from October 1 to that given date;
- The net change in reservoir storage in all reservoirs above the point of measurement completed subsequent to January 1, 1950, during the period from October 1 to that given date;

- The change in storage in existing reservoirs above the point of measurement, which is used for irrigation, municipal, and industrial purposes developed after January 1, 1950, during the period October 1 to that given date;
- The quantity of water that passed the point of measurement during the period from October 1 to that given date.

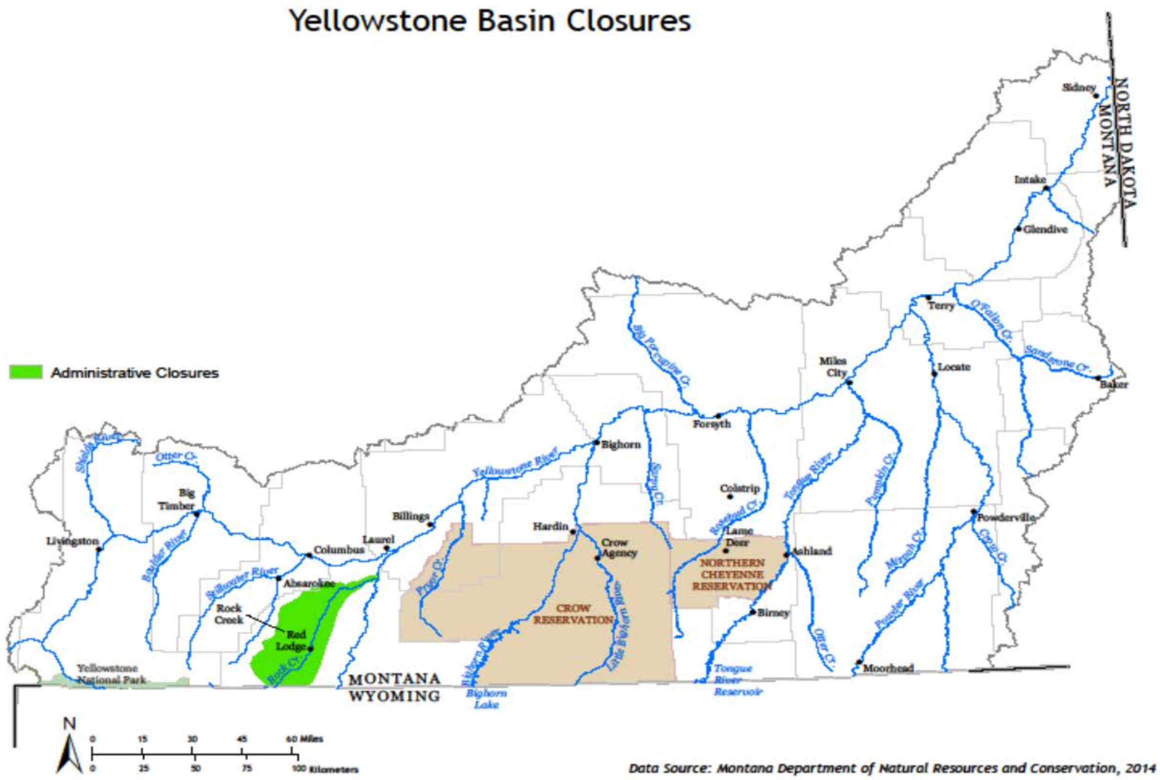
  (In all cases, the point of measurement is located at the confluence of the interstate tributaries and the Yellowstone River.)

Supplemental water for holders of water rights prior to January 1, 1950, also is subtracted from the tributary flows to determine surplus flows. Supplemental water is defined as that quantity of unused and unappropriated water necessary to fully satisfy the water requirements of pre-1950 water rights in both states and, therefore, cannot be allocated between states in the apportionment. Wyoming has independently estimated its share of the surplus flow from the four tributaries. However, Montana does not necessarily agree with these estimates. It is obvious that some of the present flow in the tributaries specified in the compact may not be available to Montana in the future because Wyoming will someday attempt to appropriate a greater share. Wyoming's share of the water in the Yellowstone Basin, as defined in terms of the Yellowstone River Compact, has not been quantified and is pending outcome of litigation currently in progress before the U.S. Supreme Court.

Yellowstone Basin Closures

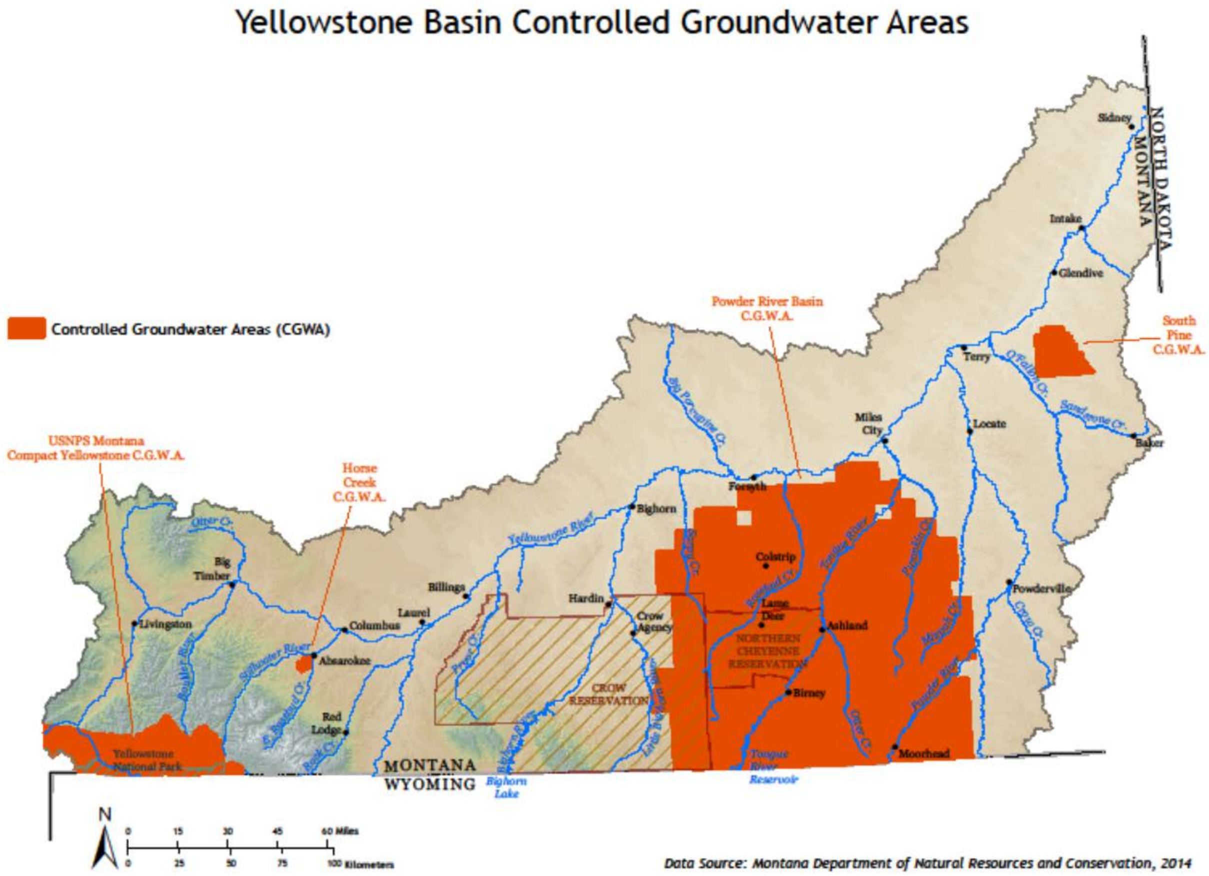
As water supplies become fully appropriated, there are mechanisms in the law to limit new appropriations further. Basins can be "closed" to new appropriations by the Legislature or through rulemaking by DNRC upon receipt of a petition by the current water users. The petition must show, and DNRC must determine, that there are no unappropriated waters in the source of supply, the rights of prior appropriators will be adversely affected by further appropriations, or that further uses will interfere unreasonably with other planned uses or developments for which a permit has been issued or for which water has been reserved. Figure VI-3 shows the basin closures in the Yellowstone Basin. Besides the Rock Creek basin closure, closures exist for Yellowstone National Park, Bighorn Canyon National Recreation Area, Little Bighorn Battlefield, and the Northern Cheyenne and Crow Reservations.

Figure VI-3 Yellowstone Basin Closures Map.



The second mechanism for placing greater control over heavily appropriated waters is through controlled groundwater areas (CGWAs). It is possible to close an aquifer to further appropriations or restrict or condition water allocations. Controlled groundwater areas can be established by DNRC by petition of the water users. Controlled groundwater areas may be created if groundwater withdrawals are in excess of recharge, excessive withdrawals are expected in the future because of recent consistent and significant increases in withdrawals, disputes in priority of rights or amounts of use are in progress, groundwater levels are declining or have declined excessively, or if contaminant migration and degradation of groundwater quality are occurring because of excessive withdrawals. Figure VI-4 shows the CGWAs in the Yellowstone Basin.

Figure VI-4 Controlled Groundwater Areas in the Yellowstone River Basin.



Montana Water Quality Law

The Montana Water Quality Act incorporates both national and state policy by integrating the directives of the federal Clean Water Act while also codifying the priorities of the Montana Constitution's environmental quality clauses. The Department of Environmental Quality (DEQ) is the state agency primarily responsible for implementing the Water Quality Act. The Governor appoints its director. (MCA § 2-15-3501) In administering water quality laws, the DEQ:

- collects and furnishes information relating to water pollution prevention and control (MCA § 75-5-212);
- conducts and encourages research relating to water pollution (MCA § 75-5-212);
- advises, consults, and cooperates with other states, other state and federal agencies, affected groups, political subdivisions, and industries in formulating pollution prevention and control plans (MCA § 75-5-213); and

- monitors, inspects, and otherwise enforces water quality laws (MCA §§ 75-5-602 and 75-5-603).

Water quality laws govern only certain state waters. Specifically regulated are surface or underground bodies of water; irrigation systems; or drainage systems. (MCA § 75-5-103(34)(a)) Outside this regulatory realm are ponds or lagoons used solely for treating, transporting, or impounding pollutants; or irrigation or land application disposal waters used up within the system and not returned to state waters. (MCA § 75-5-103(34)(b)) Montana water quality laws regulate every entity in the state, including individuals, businesses, organizations, and units of government.

Although any water use may cause an alteration in water quality, water quality laws regulate only certain uses. Regulated uses are those entailing potential pollution (either point source pollution or nonpoint source pollution) to state waters; that is, activities that threaten water quality, human or wildlife health, or established beneficial uses (MCA §§ 75-5-103(4), (30), and (31) and 80-15-102(11)).

VII. Potential Future Demands for Water in the Yellowstone River Basin

Results of Past Efforts to Estimate Future Demand

The most recent detailed water availability investigation conducted in the Yellowstone River Basin was done to support the Water Reservation process concluted by DNRC in the early 1980's (Sobashinski and Lozovoy 1982). A monthly water availability model, patterned after the U.S. Bureau of Reclamations (USBR) OP-STUDY model, was developed for key locations in the river basin and calibrated with historic flow data:

- Yellowstone R near Livingston
- Stillwater River near Absarokee
- Clarks Fork at Edgar
- Yellowstone River at Billings
- Bighorn River near St. Xaiver
- Tongue River at Miles City
- Yellowstone River at Miles City
- Powder River at Arvada
- Powder River near Locate
- Yellowstone River near Sidney

The amount of surplus water available for appropriation was estimated by accounting for all water reservations proposed by applicants and then estimating depletions (consumptive use) associated with estimated future Wyoming, Native American, and federal uses. Existing uses were accounted for using the USBR's 1975 level-of-development streamflow (streamflow depleted by consumptive uses up to 1975) and then subtracting additional depletions for provisional water-rights permits issued in Montana between 1975 and 1981. A number of assumptions were required to conduct the analysis—the most significant being allocation of water under terms of the Yellowstone River Compact and future Wyoming water development, and future allocation of federal reserved water (primarily Native American).

The monthly analyses indicated that there was not a reliable (six to eight years out of ten) supply of irrigation water available for appropriation directly from the river at any location in the basin. On an annual basis water would be available, from the mainstem, throughout the basin; however it would require off-stream storage to make the water available at a time it could be used.

Overview of Planning Scenarios

In order to estimate potential future demand for water in the Yellowstone Basin for this planning effort, several planning scenarios were developed. Because irrigation is the largest diverter and consumer of water, these scenarios focus on future development of irrigated agriculture:

Scenario 1. Historical Trends-- assumes that the trend of past water development is projected into the future at the same rate;

Scenario 2. Development of DNRC Water Reservations-- assumes that all the DNRC water reservations granted to Conservation Districts, will be fully developed;

Scenario 3. Development of Federal Reserved Water Rights-- assumes that Federal Reserve Water Rights will be fully developed; the most significant potential development includes water allocated to the Northern Cheyenne and Crow Tribes in Montana, and the Wind River Tribe in Wyoming.

Scenario 4. Full Development of Consumptive Use in Montana (Historical Trend, DNRC Water Reservations, Montana and Wyoming Tribes, Wyoming Wind-Bighorn Basin)

The planning timeline for these potential future developments is 2035.

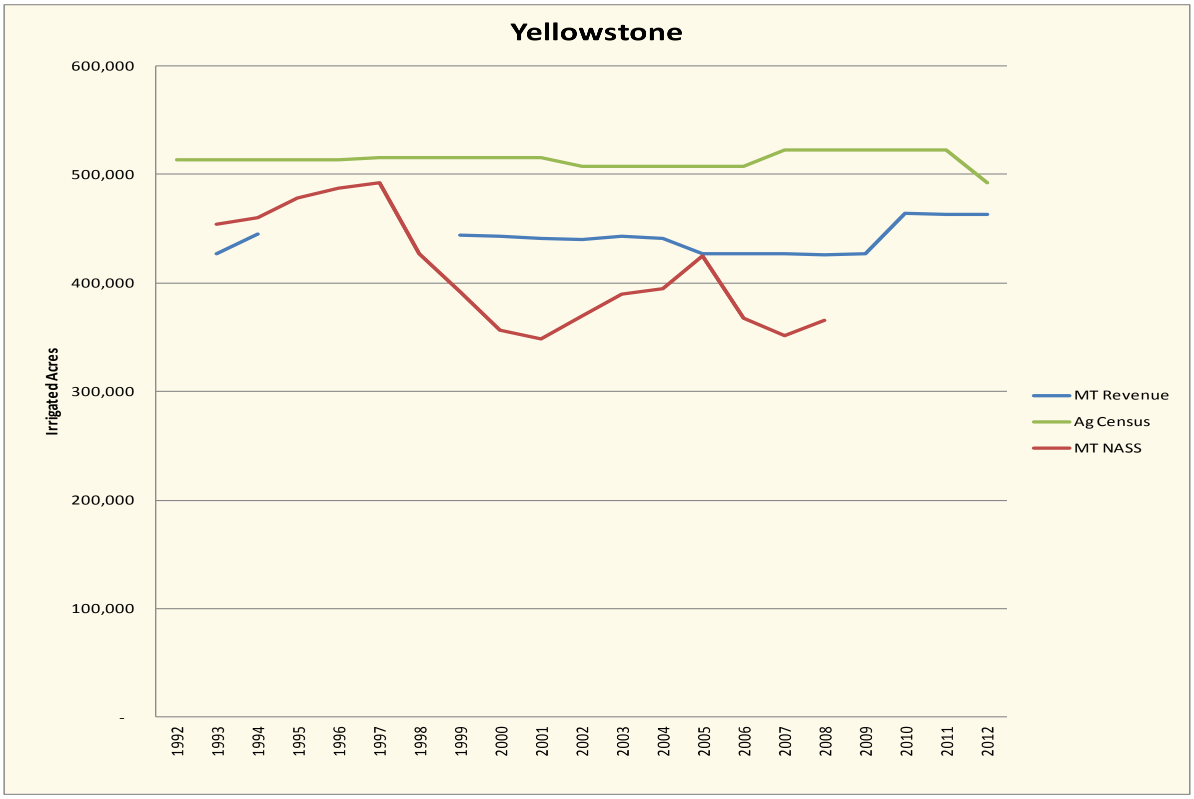
Agricultural Demand Projections

HISTORICAL TRENDS IN IRRIGATED AGRICULTURAL DEVELOPMENT

General trends in irrigated land in production, during the last twenty years in the Yellowstone River Basin, were estimated from several sources of information: the Montana Department of Revenue Final Lands Unit (FLU) mapping; the National Agricultural Statistics Service (NASS) data; and Agricultural Census Data. Although the acreages estimated as irrigated by the three sources vary, overall there does not appear to be a discernible trend of substantial increases or decreases In Yellowstone River Basin irrigation (Figure VII-1). Additional information on historical trends in irrigated acreage, on a county-specific basis, is presented in Appendix G, Section VII, Potential Future Water Demand.

Additional information examined to evaluate trends included: annual reporting on development of conservation district water reservations; review of DNRC permit applications and authorizations over the past 10 years; and review of specific proposals for infrastructure investment identified by DNRC's Irrigation Development Program. Review of the 2013 Conservation District Water Reservation Balance documentation (Table VII-1) indicates that several CD's have shown recent irrigation expansion, with the source of water generally limited to the Yellowstone River; these include, Big Horn, Custer, Powder River, Richland, Sweet Grass, Yellowstone CD's. Review of DNRC permit information indicates that the Yellowstone Basin, above Bridger Creek and Sweetgrass Creek have seen the most active development.

Figure VII-1 Trends in Yellowstone River Basin Irrigated Acreage 1992- 2012.



DNRC's Irrigation Development Program (Technical Memorandum 2.4 Emerging Opportunities for Sustaining or Expanding Irrigated Agriculture in Montana, DNRC CARDD 2008) identified the West Crane Project (10,000 to 15,000 acres located west of Sidney) as a possible future development; the project would rely on the Richland CD's Water Reservation. Although an irrigation district was formed in the early 2000's, the project was never developed and is not currently being pursued.

Review of the Yellowstone River Basin CD's Water Reservation Balance (as of 12-31-2013) indicates that since the reservations were granted about 35 years ago, 209 projects have been developed using about 17 (95,000 acre-feet) percent of the total water allocated (548,000 acre-feet) (see Table VI-2). The most active counties, in terms of the amount of their reservation developed, have been Bighorn, Custer Powder River, and Richland, and Powder River.

Figure VII- 2 Wheel-line sprinkler irrigation in the Yellowstone River Basin.

Municipal and Domestic Demand Projections

The population within the Yellowstone River Basin is likely to continue growing along with the demand for water to meet municipal and domestic purposes. If the basin's population continues to grow at the same rate as seen from 1990 to 2010 (based on census data), it will have an additional 64,000 residents, mostly in the Billings area (see Chapter III - Basin Profile). If the population growth rates based on census data continue, DNRC estimates that by 2035 consumption by public water supplies and self-supplied domestic water will increase 5,436 acre-feet or about 36 percent.

Municipal water suppliers may need to increase their delivery capacity and new public water supply systems may be constructed. Unless laws change regarding exempt wells, the proliferation of self-supplied domestic wells will likely continue as rural populations expand, primarily in the upper parts of the Basin and particularly around the Billings metropolitan area.

Population growth projections correspond directly to increased (or decreased) demands for domestic and municipal water uses. In order to estimate future domestic water demands, population projections were created for Montana's portion of the Yellowstone Basin to the year 2035. Projections were made for each sub-basin (8-digit hydrologic unit code) and were based on U.S. Census population estimates during the period 1990 – 2010 (see Table VII.1). For a map showing sub-basin names, see Figure IV-4.

Table VII-1 Population Projections – Yellowstone Sub-Basins 2035 based on 1990-2010 Trends

		Estimated	Estimated
		Population	Percent Change
SUB-BASIN	2010	2035	2010-35
Big Horn Lake	10	3	-70
Big Porcupine Creek	108	79	-27
Clarks Fork Yellowstone River	10,013	13,274	33
Little Bighorn River	4,662	5,056	9
Little Powder River	271	150	-45
Lower Bighorn River	5,646	6,733	19
Lower Powder River	327	229	-30
Lower Tongue River	7,139	6,893	-3
Lower Yellowstone River	19,143	17,603	-8
Lower Yellowstone River-Sunday Creek	12,012	10,568	-12
Middle Powder River	796	630	-21
Mizpah Creek	221	241	9
O'Fallon Creek	2,723	2,463	-10
Pryor Creek	1,457	1,791	23
Rosebud Creek	4,253	5,376	26
Shields River	1,957	2,354	20
Shoshone River	31	26	-16
Stillwater River (Yellowstone R)	3,102	3,981	28
Upper Tongue River	148	90	-39
Upper Yellowstone River	16,455	18,454	12

The Yellowstone was the third fastest growing major river basin in Montana between 1990 and 2010, with the population increasing by 19 percent to 245,062. The populations of the Upper Yellowstone-Pompeys Pillar and the Upper Yellowstone-Big Lake Basin increased by 47 percent and 26 percent, respectively, between 1990 and 2010. In contrast, the Upper Tongue River and Lower Powder River sub-basins saw decreases in population of 33 percent and 25 percent, respectively, during the period. Twelve of the basin's 23 sub-basins experienced population declines while 11 experienced population increases.

Based on these trends, total Yellowstone Basin population is projected to increase by 59,364 (24 percent) by 2035. Much of the increase is projected to occur in the sub-basins around Billings. However, throughout much of the Yellowstone River Basin, particularly in the east and southeast, a declining population is projected. To avoid underestimation of future domestic water demand, stable populations were assumed and negative growth trends (declining populations) were replaced with zero loss or zero growth figures for 2035.

The eleven sub-basins (8-digit HUCs) showing projected population increases are:

- Clarks Fork Yellowstone River (33%): A major tributary to the Yellowstone River whose watershed is primarily in Carbon County.
- Little Bighorn River (9%): A tributary of the Bighorn River whose watershed is primarily within the Crow Reservation.
- Lower Bighorn River (19%): A major tributary of the Yellowstone River whose watershed in Montana is primarily within the Crow Reservation.
- Mitzpah Creek (9%): A tributary to the Powder River whose watershed is approximately equally divided between Custer County and Powder River County.
- Pryor Creek (23%): A tributary of the Yellowstone River near Billings. Much of the upper watershed is within the Crow Reservation for which a water compact has been completed. The lower portion is in Yellowstone County.
- Rosebud Creek (26%): A tributary of the Yellowstone River whose watershed is primarily within the Northern Cheyenne Reservation for which a water compact has been completed.
- Shields River (20%): A tributary of the Yellowstone River whose watershed is primarily within Park County. Drains the west side of the Crazy Mountains and the east side of the Bridger Mountains.
- Stillwater River (28%): A tributary of the Yellowstone River whose watershed is primarily within Stillwater County. Drains the north and east sides of the Absaroka-Beartooth Plateau.
- Upper Yellowstone River (12%): Upper Yellowstone River basin primarily in Park and Sweetgrass Counties. Drains the west side of the Absaroka-Beartooth Plateau and east side of the Gallatin Range.
- Upper Yellowstone River-Big Lake Basin (34%): Includes the main stem of the Yellowstone River from upstream of Columbus to Billings. Includes the west side of Billings.
- Upper Yellowstone River-Pompeys Pillar (61%): Includes the main stem of the Yellowstone River from Billings to the Treasure County Line. Includes the Billings metropolitan area.

Based on the 2035 population estimate, the following assumptions were used to estimate future water demand in the Yellowstone River Basin:

- Percentages of population by HUC served by Public Water Supply (PWS) and individual wells were assumed to be constant over time.
- Percentages of PWS supplied by groundwater in each sub-basin are assumed to be constant over time.
- Gallons per Capita Daily (gpcd) for PWS users in each sub-basin is assumed to be constant over time.
- 37% of water diverted for PWS is consumed. This is consistent with present day (2010) estimates.
- Self-Supplied Domestic Water (SSD) users = the total population in a sub-basin (8-digit HUC) minus those served by PWS.
- New SSD water use is assumed to be supplied entirely by groundwater.
- SSD water use = 75 gpcd, of which 50% is assumed to be consumed. This is consistent with present day (2010) estimates.

Estimates were made for two types of usage: Public Water Supplies (PWS) as identified from state and federal regulatory sources, and Self-Supplied Domestic (SSD). Numbers of SSD systems were calculated by assuming that people not served by a PWS were served by a SSD system. Figure VII-3 shows the current (2010) Public

Water Supply (PWS) demand, the projected increase in demand and the total demand of PWS at 2035 in Yellowstone sub-basins that have a positive population growth trend. The figures are in acre-feet annually.

By far the largest existing demand, and the largest potential increase in demand is in the Billings metropolitan area, especially that portion of the basin comprised by the Upper Yellowstone River - Big Lake sub-basin. This sub-basin includes western Yellowstone County and a significant portion of Stillwater County. Presumably, individual PWSs (for example, the City of Billings) that have the potential to experience significant growth have developed specific demand projections and plans to meet the needs of an expanded customer base. For the rest of the sub-basins, none of the projected increase in demand is large enough to represent a significant threat to overall water availability within a given sub-basin.

Figure VII-4 shows the current (2010) SSD, the projected increase in demand, and the total demand of SSD at 2035 in Yellowstone sub-basins that have a positive growth trend. Here again, the greatest increase in demand is projected in those sub-basins that include the Billings metropolitan area: 1) Upper Yellowstone River - Big Lake and 2) Upper Yellowstone River - Pompeys Pillar sub-basins. The remaining nine sub-basins have projected increases less than 100 acre-feet. By themselves, these increases do not represent significant quantities of water when compared to the overall water supply. However, SSD systems are almost exclusively supplied by groundwater and while impacts associated with the development of individual systems may be individually insignificant, cumulatively they may have a significant effect. Also, depending on local circumstances such as aquifer characteristics and proximity to other users they may adversely affect existing users, which Montana law prohibits.

Figure VII-3 Projected Public Water Supply in 2035.

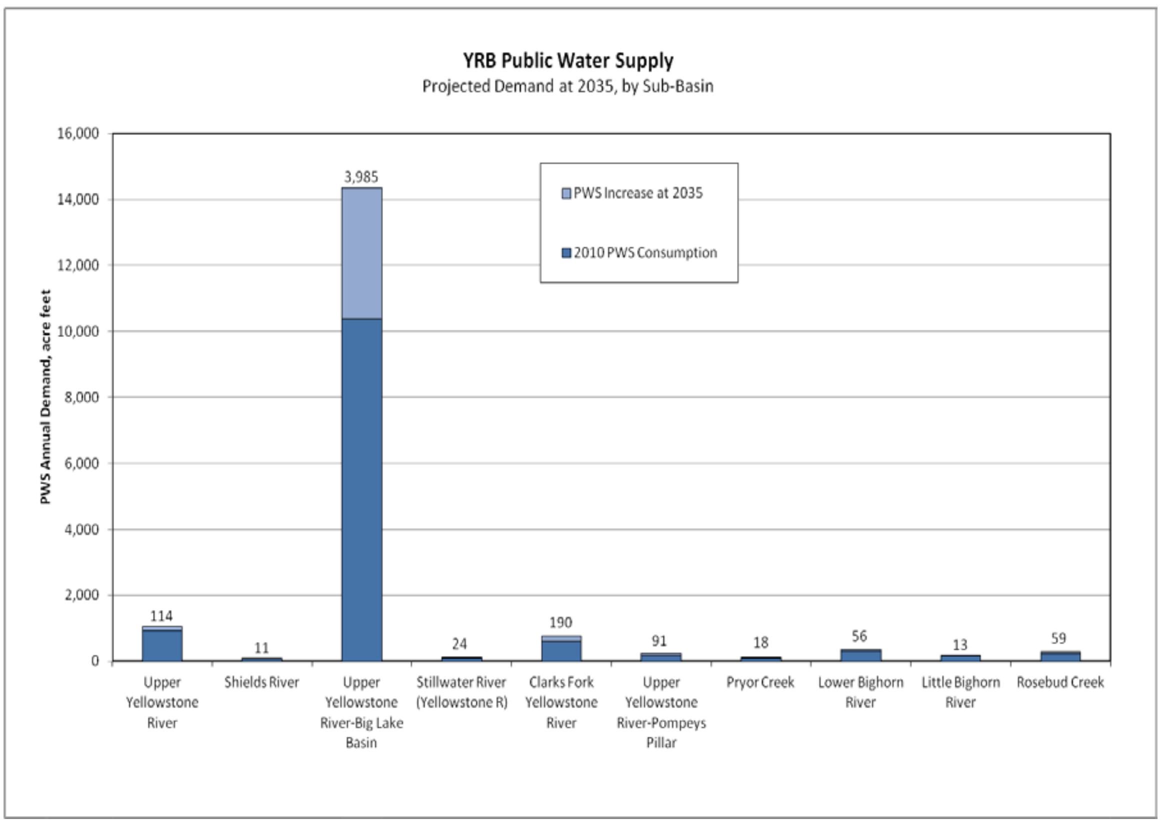
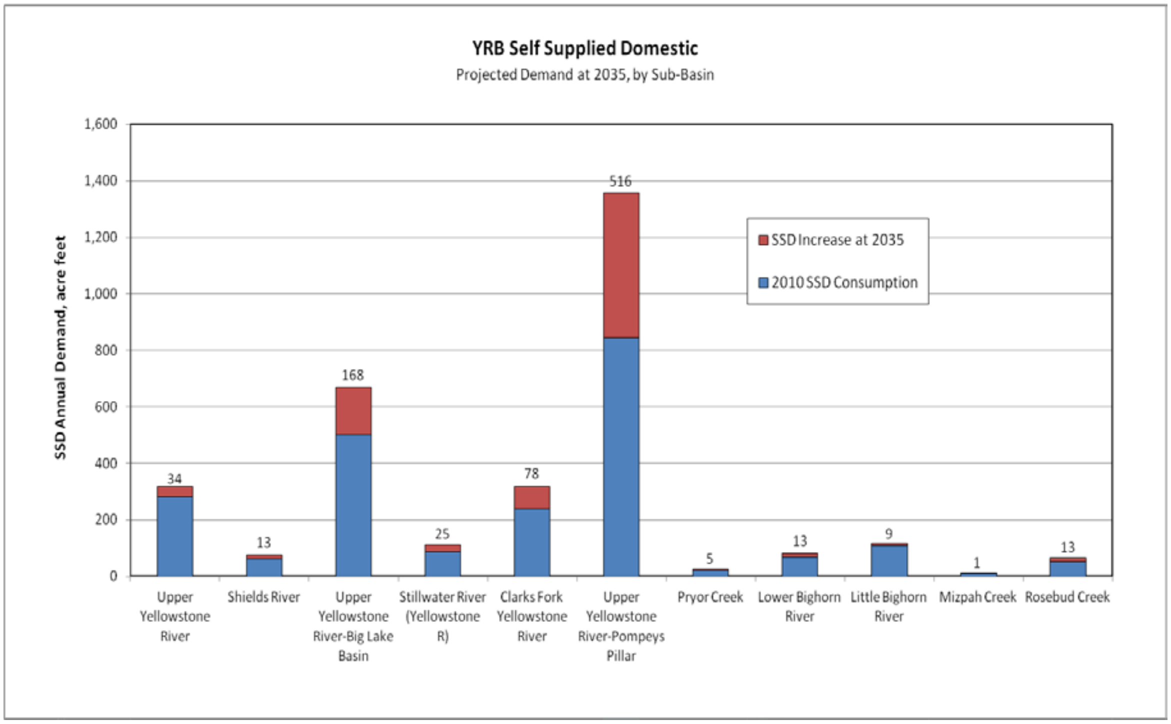


Figure VII-4
Projected Self-Supplied Domestic in 2035.



Industrial Demand Projections

Water demands 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 fracking for oil and gas extractions, potential coal-to-liquid (CTL) fuel facilities, and mining, are not served by public water supplies and do not follow predictable trends.

Instream Flow Demand Projections

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 fish license sales, and the potential for endangered species listing (see Chapter III - Basin Profile, Environmental Concerns) all may affect the magnitude and regional pattern of demand for instream flows.

Physical components of riverine systems that affect the biota both in the riparian and instream areas include hydrology, geomorphology, and water quality. The results of the Yellowstone River Conservation District Council (YRCDC) sponsored Yellowstone River Cumulative Effects Assessment has shown that significant changes have occurred to all three of these system components as a result of water development and construction of structures within the floodplain.

Meeting the long-term demand for instream flow means providing for the long-term sustainability of the Yellowstone River ecosystem including its tributaries. Instream flow requirements for endangered species, such as the pallid sturgeon, need to be determined, and the specific recommendations set forth by the Yellowstone Basin Advisory Committee (see Instream Flow Maintenance in Chapter IX) need to be pursued by implementation of Best Management Practices being developed by the YRCDC.

Analysis of Consumptive Irrigation, Water-Demand Scenarios

SCENARIO 1. HISTORICAL TRENDS TO 2035

Examination of the 1992 to 2012 agricultural trend data (Figure VII-1) for the upper, middle and lower Yellowstone sub-basin, indicates that the amount of irrigated acreage has remained stable or declined in some cases (see Appendix G, Section VII, Potential Future Water Demand)—although there is considerable fluctuation between years. For this analysis it is assumed that the irrigated acreage mapped for the current plan (2007) is representative of the sub-basins and will not increase or decrease by the year 2035. (Note that the CD reservations for 95,000 acre-feet were allocated prior to 1992, and are included in the Figure VII-1 data).

SCENARIO 2. DEVELOPMENT OF DNRC/CD WATER RESERVATIONS TO 2035

For this analysis it is assumed that the DNRC Water Reservations granted to the Yellowstone CD's for irrigation are fully developed (including the West Crane project in Richland County). This amounts to developing an additional 255,000 acres of irrigation that would require a diversion of approximately 477,000 acre-feet and would consume approximately 382,000 acre-feet of water per year. Given the current flat trend in development of irrigated acreage in the Yellowstone Basin, and recent experience with the West Crane Project, it is unlikely that this development will occur by 2035, however it represents an upper limit of development of irrigated agriculture.

SCENARIO 3. DEVELOPMENT OF FEDERAL RESERVED WATER RIGHTS

The most significant potential development includes water allocated to the Northern Cheyenne and Crow Tribes in Montana, and the Wind River Tribe in Wyoming. Table VII.2 summarizes the Federal Reserved Water Rights of the Montana tribes

NORTHERN CHEYENNE TRIBE (FEDERAL RESERVED WATER RIGHT AND COMPACT)

(See Chapter VI. for a description of the Compact)

CROW TRIBE (FEDERAL RESERVED WATER RIGHT AND COMPACT)

(See Chapter VI. for a description of the Compact)

WIND RIVER TRIBE (FEDERAL RESERVED WATER RIGHT AND COMPACT)

After 37 years of effort, the Bighorn Basin's adjudication's final decree was signed on September 5, 2014. A significant part of the seven phase adjudication was to establish Federal Reserved water rights for the Wind River Tribe and reconcile state water rights for existing and future uses in the Bighorn basin. One of the problems that is still being resolved is how to reconcile the Tribal water right that is measured as a volume of water, with the state's rights that are measured as a flow rate.

The Wyoming Water Development Commission's (WWDC) 2010 report examined low, medium, and high water use scenarios in the Bighorn Basin. The medium and high water use projects include development of Tribal Futures Projects. Through the Big Horn Adjudication, the courts determined that the Tribes were entitled to divert 499,862 acre-feet per year with a July 3, 1868 priority date. Approximately 290,500 acre feet of these water rights have been historically used for irrigation on the Wind River Indian Reservation. The remaining 209,400 acre-feet is for potential development of future irrigation projects (or Futures Projects), including the North Crowheart, South Crowheart, Arapahoe, Riverton East, and Big Horn Flats Projects, which would irrigate an additional 53,760 acres the Wind River Reservation. Separately, the Tribes compiled their own set of non-agricultural water development prospects as described in the River Water Plan of 2007. This plan identified such activities as a bottled water plant, a rangeland water system, small-scale hydrogeneration, off-stream storage for recreation and other purposes, light industrial uses, cultural water uses, and community parks and gardens.

The WWDC's 2010 report concludes that current total annual diversions in the Bighorn Basin are about 3.3 million acre-feet with a consumptive use of approximately 1.2 million acre-feet. Their medium and high water use projections indicate an increase in consumptive use by 240,000 to 830,800 acre-feet—with much of this anticipating development of the Wind River Tribal water right. [Note that the use of Wyoming Water Planning information on consumptive use of water is not an endorsement of its accuracy].

Table VII-2 Yellowstone River Basin: Federal Reserved Water Right Tribal Compact Quantifications in Montana

		Flow (CFS)	Volume (Acre feet)	Acres	
Crow					
	The Tribes are entitled to 500,000 AFY from Bighorn River and tribs, and groundwater for tribal uses. Tribe agrees to share shortages.		500,000		
	The Tribes are entitled to 300,000 AFY from storage in Bighorn Lake. Of the storage right, 150,000 AFY may be put to use in addition to natural flow right and 150,000 AFY may be used only to supplement natural flow during shortages.		300,000		
	The Tribe may use all available surface and groundwater on the reservation within Little Bighorn River and Pryor Creek Basins not needed to satisfy current water use.				
	The Tribe may use all available surface and groundwater on the reservation in Rosebud Creek not needed to satisfy Northern Cheyenne Compact.				
	47,000 AFY on Ceded Strip, but must share shortages		47,000		
	Tribe has rights to all surface flow, groundwater and storage in eight other basins on the Reservation (43O, 43E, 42A, 42B, 42KJ, 43D, 43N, 43Q). Tribe agrees to share shortages.				
	Protection of existing state-based rights				
	State administers State rights and Tribe administers Tribal rights through a water code.				
	State contribution for economic and infrastructure improvement $15m				
	TOTAL		**847,000**		
Northern Cheyenne					
	Financial contributions toward enlargement and rehab of Tongue River Dam				
	additional contributions				
	32,500 AFY from Tongue River: Direct flow right up to 12,500 AFY with limitations on depletion, and storage and exchange water up to 20,000 AFY fro a combination of Tongue River Reservoir and exchange water.		32,500		
	1800 AFY from Rosebud Creek for agricutural purposes with limitations on irrigated acreage.		1,800		
	19530 AFY from Rosebud for any purpose		19,530		
	Moratorium on new uses on Rosebud Creek				
	Groundwater may be withdrawn in lieu of surface water.				
	30,000 AFY stored water in Big Horn Reservoir		30,000		
	State administers State rights and Tribe administers Tribal rights through a water code.				
	TOTAL		**83,830**		
	(Source: DNRC-RWRCC 10-2014				

SCENARIO 4. FULL DEVELOPMENT OF CONSUMPTIVE USE IN MONTANA (HISTORICAL TREND, DNRC WATER RESERVATIONS, MONTANA AND WYOMING TRIBES, WYOMING WIND-BIGHORN BASIN)

Scenario 4 represents an upper limit of future development of consumptive use in the Yellowstone Basin; it is assumed that DNRC Water Reservations, Tribal Compact water and Wyoming water development (in the Wind-Bighorn basin) will all take place by 2035. This contains significant uncertainty because it is unclear how the federal reserved water rights for the tribes will be developed, how much water will be devoted to irrigation, and how quickly the water will be put to use?

An additional uncertainty is physical availability. It is unlikely that full development of consumptive uses, as assumed in Table VII-3, can occur without additional storage in the Yellowstone Basin. The Northern Cheyenne Tribal Compact provides for allocation of water out of Tongue River and Bighorn Reservoirs; the Crow Compact provides for allocation from Bighorn Reservoir. Full development of DNRC Water Reservations would also require additional storage in the basin.

Results of Scenario Analysis

Table VII-3 summarizes consumptive use estimates for the four scenarios. The estimates range from a low of 1,970,000 acre-feet per year to a high of 3,500,000 acre-feet per year.

Table VII-3-Yellowstone River Basin Assumed Future Agricultural Consumptive Use -- Year 2035

Consumptive Use	Current Consumption (acre-feet)	Scenario 1: Historical Trend (acre-feet)	Scenario 2: DNRC Water Reservations--Full Development (acre-feet) Plus Historical Trend	Scenario 3A, 3B, 3C: Federal Reserved Water Rights-Full Development of Tribal Water Plus Historical Trend				Scenario 4: Full Development of All consumptive Uses
				Montana		Wyoming		
				A. Northern Cheyenne	B. Crow	C. Wind River		
Irrigation	1,830,000	1,830,000	2,210,000[1]	1,860,000[2]	2,130,000[3]	2,630,000[4]		3,334,000[5]
Reservoir Evaporation	47,000	47,000	47,000	47,000	47,000	47,000		47,000
Thermoelectric	27,000	27,000	27,000	27,000	27,000	27,000		27,000
Municipal	36,000	40,561	40,561	40,561	40,561	40,561		40,500
Livestock Watering	15,000	15,000	15,000	15,000	15,000	15,000		15,000
Domestic	2,900	3,775	3,775	3,775	3,775	3,775		3,800
Industrial	2,000	2,000	2,000	2,000	2,000	2,000		2,000
Total Consumption	1,960,000[6]	1,970,000[6]	2,350,000[6]	2,000,000[6]	2,270,000[6]	2,770,000[6]		3,500,000

[1]Assumes that irrigation water reservations are fully developed resulting in consumption of 382,000 acre-feet plus the historical trend consumption of 1,830,000 acre-feet

[2]Assumes that 84,000 acre-feet are available for tribal diversion and 35% is consumed resulting in 30,000 acre-feet consumption plus historical trend of 1,830,000 acre-feet

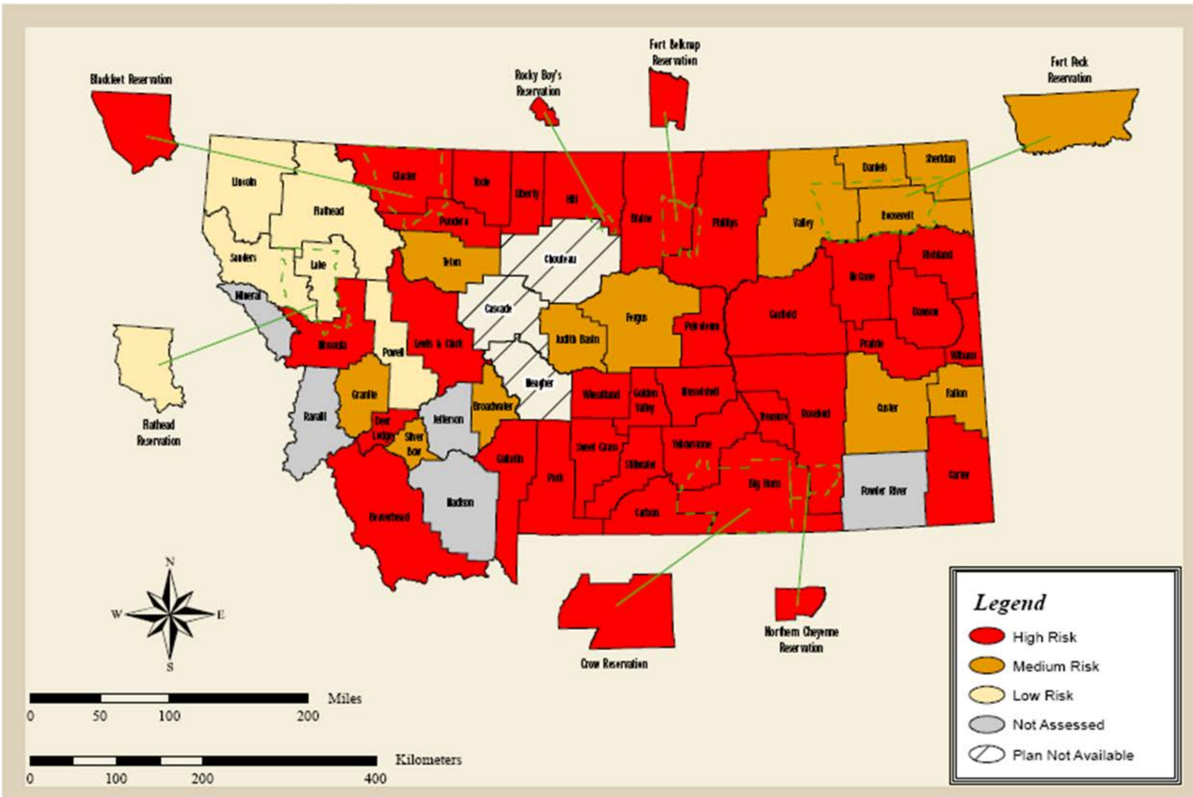
[3]Assumes that 850,000 acre-feet are available for tribal diversion and 35% is consumed resulting in 300,000 acre-feet consumption plus historical trend of 1,830,000 acre-feet

[4]Assumes upper level of Wind-Bighorn development that includes full development of Wind River Tribal allocation and other Wyoming water developments totaling 800,000 acre-feet consumption plus historical trend consumption of 1,830,000 acre-feet

[5]Sum of consumptive uses : historical trend (1,830,000)+ water reservations (382,000) + Northern Cheyenne (30,000) + Crow Tribe (300,000) + Wind River Tribe (800,000) =3,340,000 acre-feet total consumptive use

[6]Note that these numbers have been rounded.

Figure VII-5 Montana map of relative risk from drought. Most counties in the Yellowstone Basin are at High Risk for drought conditions.



Yellowstone River Basin: Potential Effects of Climate Change on Future Water Supplies and Demands

As Montana's population continues to grow, water usage and demand for water will increase. Available supplies have also increased over the years through a variety of structural (dams) and non-structural (conservation) means, but the ability to create new levels of supply in the Yellowstone Basin is limited. Consequently much of Montana and most of the Yellowstone River Basin is at high risk from the effects of drought (Figure VII-5).

Traditionally, water planning assessments have assumed that future water supply conditions will be similar to what they have been in the past, recognizing that the exact sequencing of past flow patterns will not be repeated. An overwhelming preponderance of scientific evidence shows that the future envelope of streamflow variability will differ from the historical. Warming has occurred over much of the U.S. during the latter part of the 20th century and is highly 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 rate of evaporation from soil and open water, 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 examines how climate change in the Yellowstone River Basin is likely to affect future water supply and demand. This information can be used to evaluate the ability to meet future water demands within the basin and to identify strategies for adapting to changing water supplies.

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 the U.S. Bureau of Reclamation at: http://gdo-dcp.ucllnl.org/downscaled_cmip_projections/.

Climate change simulations for temperature, precipitation, evapotranspiration, snowpack and streamflow were prepared for the Upper Yellowstone Sub-basin (above Billings); graphic results are summarized in Figure VII.6 to VII.10 (see Appendix H, Section VII, Potential Effects of Climate Change).

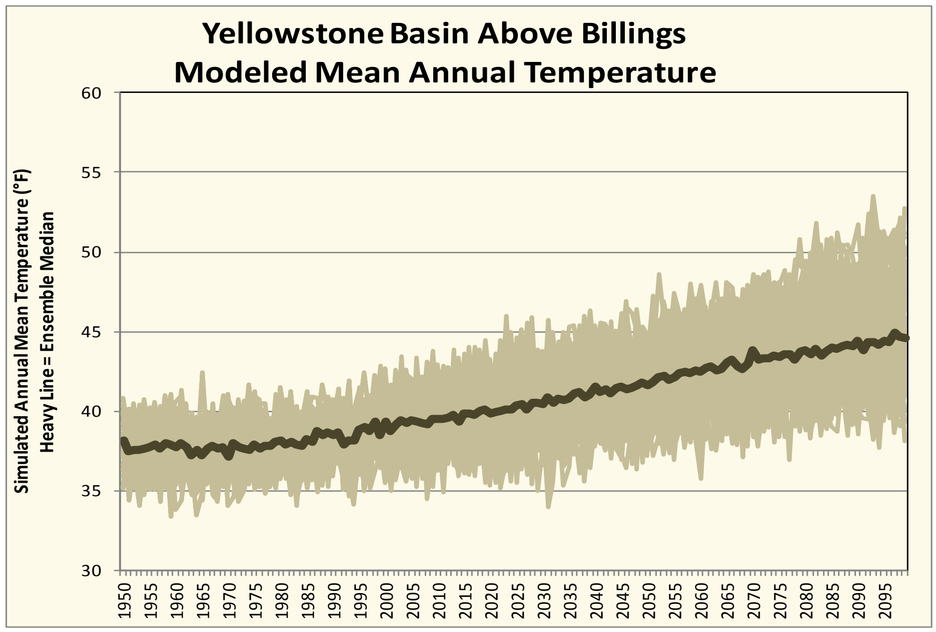


Figure VII- 6 Mean annual temperature simulations from 112 GCM models. Solid brown line represents median change.

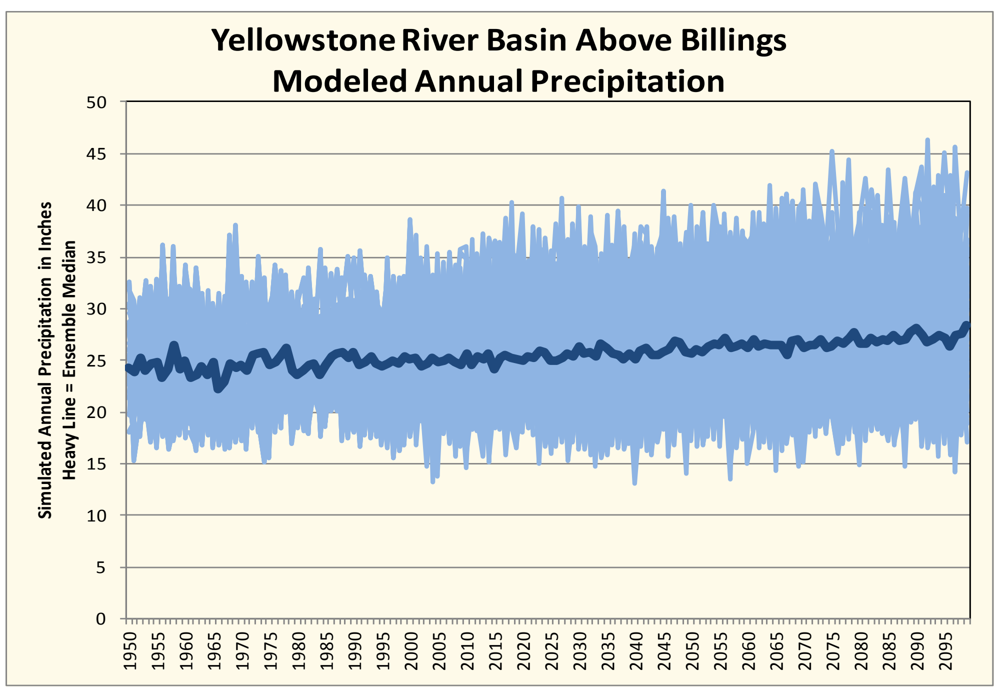


Figure VII-7 Annual precipitation simulations from 112 GCM models. Solid blue line represents median change.

Figure VII-8 Modeled changes median April 1 snow water equivalent (SWE) for the Yellowstone River Basin headwaters. Solid blue line represents median change.

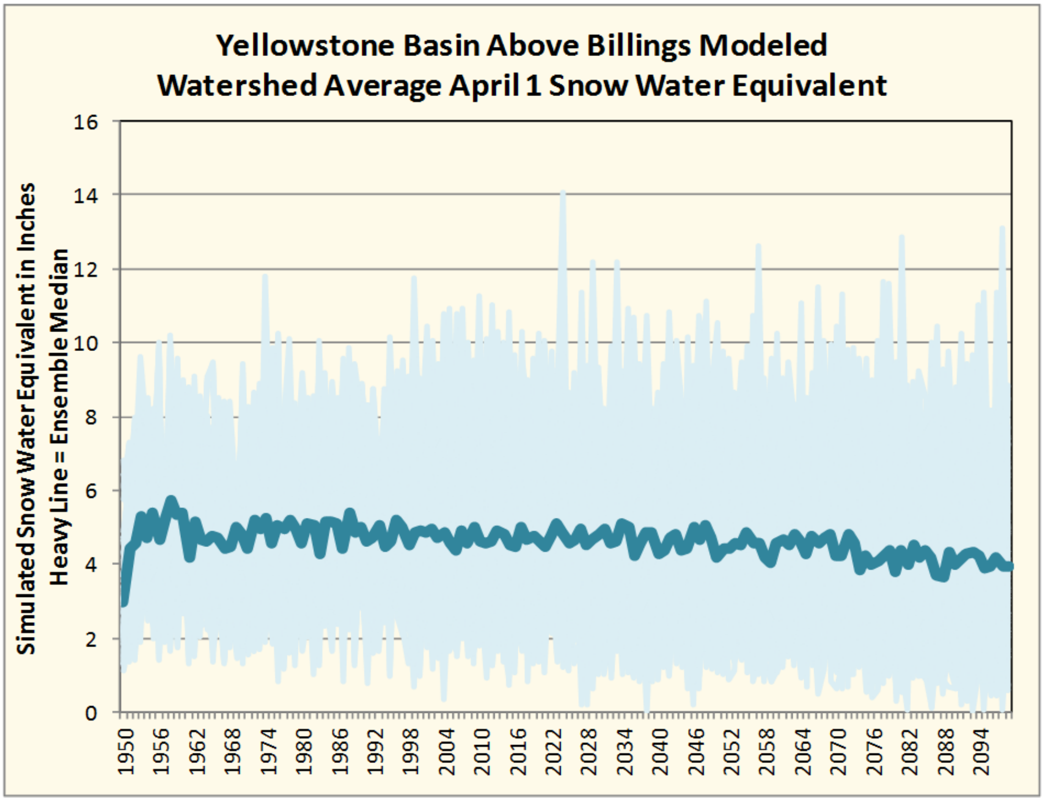
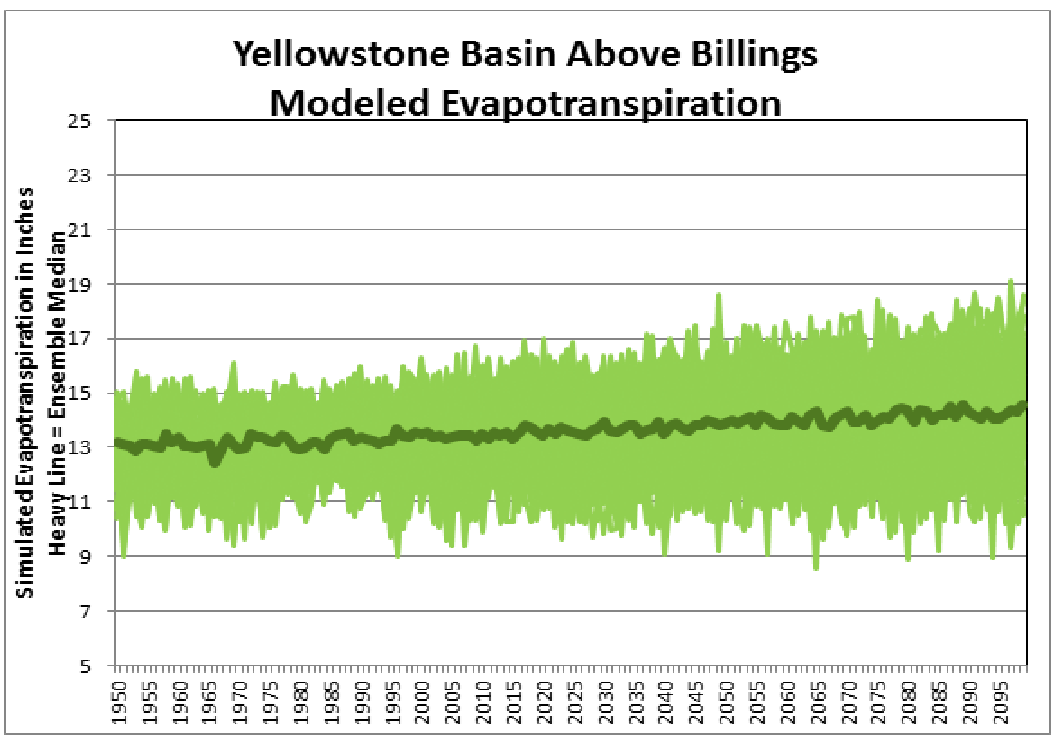


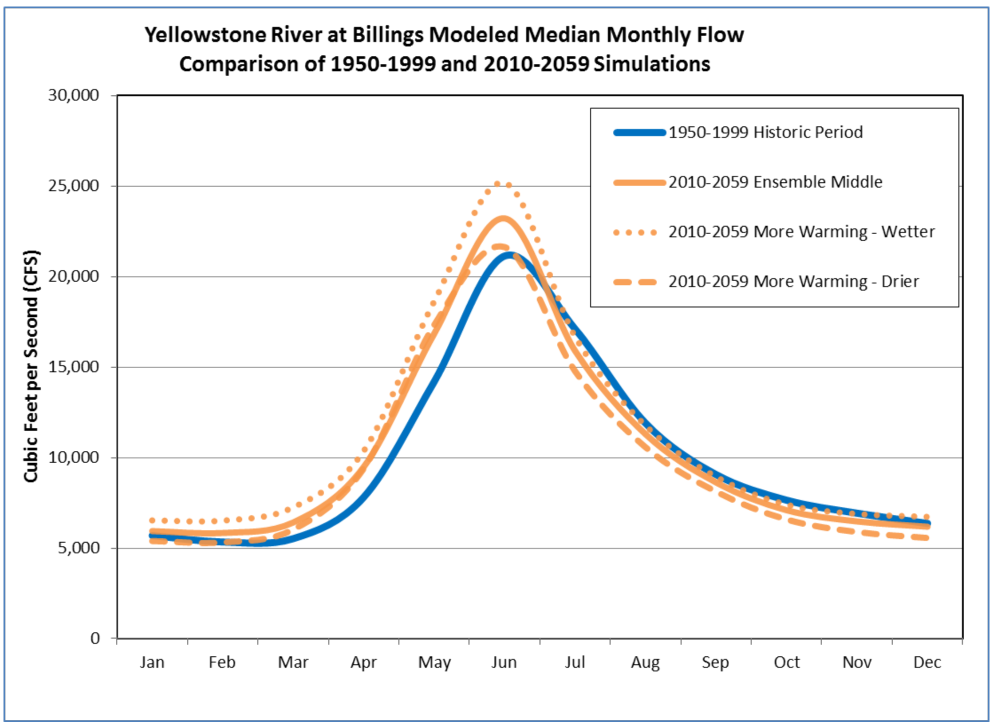
Figure VII-9 Modeled changes median evapotranspiration for natural vegetation in the Yellowstone River Basin headwaters. Solid green line represents the median change.



STREAMFLOW

Figure VII-8 compares simulated median (essentially average) streamflow, for the future 2010-2059 period to the historic 1950-1999 period). 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 reservoir regulation and effects of irrigation on return flow and flow depletion. However the analysis does provide an idea of how flow volumes and timing of runoff may change in the future. Figure VII-6 presents several curves that represent: 1) the average of the 112 simulations of climate change effects, which indicates approximately a 12 percent increase in monthly runoff over the historic period for the peak runoff month of June; 2) a 25% increase in June runoff for the 2010-2059 climate change scenario representing a warmer, but wetter climate; and 3) a slight increase in June runoff for the 2010-2059 warmer, but drier climate. All of the streamflow change estimates indicate an advance in peak runoff on the order of two to three weeks. From the information presented previously on climate, it is evident that some of these changes are already occurring in the basin.

Figure VII-10 Modeled median monthly flow for the Yellowstone River Headwaters under historical conditions and future climate scenarios.



In the future, flow produced in the Yellowstone River Basin might be of similar volume to what has been produced in the past, with shifts in streamflow timing and the wetter scenarios showing increased overall runoff. 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.

FUTURE WATER DEMANDS

All of the 112 simulations project increased temperature in the Yellowstone River Basin and most show modest precipitation increases. The increase in temperature could result in increased water demands, especially for irrigation. 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 Figure VII-9 depicts potential ET for natural vegetation, it does indicate that ET demand will likely increase from agricultural crops as well.

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. And the 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.

VIII. Options for Meeting New Water Demands

Basins with Unallocated Water

Overall, the availability of water for new appropriations varies across the Yellowstone River Basin and is subject to both physical water availability and existing legal demands. Montana has the authority to restrict or close river basins and aquifers to future withdrawals, based on concerns to protect existing uses, water quality issues, and additional water shortages. Exceptions may be available for various consumptive and non-consumptive uses depending upon the closure. Applications for new groundwater uses are not prohibited in closed basins, but they generally require reallocating water from an existing surface water or groundwater use through a mitigation or aquifer recharge plan. Options have increased in recent years to facilitate mitigation and mitigation banking as explained below.

Opportunities for new appropriations for surface water or hydraulically connected groundwater may also be limited outside closed basins because of irrigation claims, hydroelectric rights, or instream water rights for fisheries; the Yellowstone River downstream of the Bighorn River is an exception as are intermittent and ephemeral drainages in eastern Montana. Surface water is available seasonally or on limited reaches of other streams. The potential for new appropriations of groundwater from aquifers that are hydraulically connected to surface water is typically limited by the legal availability of flows in the connected surface water source.

Montana is a “prior appropriation” state, and must first protect existing senior water uses before allowing additional demands on water resources. Physical water availability, if any, is based on surplus water above and beyond existing, water uses with valid water rights. An applicant for water use must prove that their proposed future use of water does not impact existing user’s surface or groundwater allocation.

Table VIII-1 summarizes general legal availability of surface water for appropriation in the Yellowstone River Basin. The summary is based on past permitting records and experience of DNRC Billings and Bozeman Regional Office personnel. New appropriations from aquifers hydraulically connected to these streams and rivers also may be subject to limitations.

Table VIII-1 Billings and Bozeman Regional Office Indicators of Legal Water Availability

Billings Regional Office

Water Source	Legally Available?	Comments
Bighorn River	Yes	Below the Crow Indian Reservation
Big Porcupine Creek		No water rights issued since 1995
Bitter Creek Drainage	No-Basin Closure	Crow Compact – Effective June 22, 1999 - Within Yellowstone River Basin between Clarks Fork Yellowstone River and Bighorn River & Reservation

Billings Regional Office Continued

Water Source	Legally Available?	Comments
Blue Creek Drainage	No-Basin Closure	Crow Compact – Effective June 22, 1999 - Within Yellowstone River Basin between Clarks Fork Yellowstone River and Bighorn River & Reservation
Bluewater Creek Drainage	No-Basin Closure	Crow Compact – Effective June 22, 1999 - Within Clarks Fork Yellowstone River Basin & Reservation
Clarks Fork Yellowstone River	Near the mouth	May be available elsewhere on the source, however no water availability analysis has been performed recently
Cottonwood Creek Drainage	No-Basin Closure	Crow Compact – Effective June 22, 1999 - Within Clarks Fork Yellowstone River Basin & Reservation
Dry Creek Drainage	No-Basin Closure	Crow Compact – Effective June 22, 1999 - Within Tongue River Basin & Reservation
Dry Creek Drainage	No-Basin Closure	Crow Compact – Effective June 22, 1999 - Within Yellowstone River Basin between Clarks Fork Yellowstone River and Bighorn River & Reservation
Five Mile Creek Drainage	No-Basin Closure	Crow Compact – Effective June 22, 1999 - Within Clarks Fork Yellowstone River Basin & Reservation
Fly Creek Drainage	No-Basin Closure	Crow Compact – Effective June 22, 1999 - Within Yellowstone River Basin between Clarks Fork Yellowstone River and Bighorn River & Reservation
Little Bighorn River Basin (43O)	No-Basin Closure	Crow Compact – Effective June 22, 1999
Little Powder River	?	
Lower Powder River	No	No water rights issued since 1995
Mizpah Creek	No	No water rights issued since 1995
Powder River	Below Broadus	
Pryor Creek Basin (43E)	No-Basin Closure	Crow Compact – Effective June 22, 1999
Rock Creek	No-Basin Closure	ARM 36.12.1013 - Effective February 2, 1990 - Diversion from June 1 through September 30 are prohibited

Billings Regional Office Continued

Water Source	Legally Available?	Comments
Rosebud Creek Basin (42A)	Moratorium / Basin Closure	Northern Cheyenne Compact - Effective May 20, 1991 Crow Compact – Effective June 22, 1999 Applies to Rosebud Creek Basin reservation
Stillwater River	?	Highly appropriated.
Sage Creek Drainage	No-Basin Closure	Crow Compact – Effective June 22, 1999 - within Shoshone River Basin & Reservation
Sarpy Creek Drainage	No-Basin Closure	Crow Compact – Effective June 22, 1999 - Within Yellowstone River Basin between Bighorn River and Tongue River & Reservation
Spring Creek Drainage	No-Basin Closure	Crow Compact – Effective June 22, 1999 - Within Tongue River Basin & Reservation
Squirrel Creek Drainage	No-Basin Closure	Crow Compact – Effective June 22, 1999 - Within Tongue River Basin & Reservation
Sage Creek Drainage	No-Basin Closure	Crow Compact – Effective June 22, 1999 - within Shoshone River Basin & Reservation
Tanner Creek Drainage	No-Basin Closure	Crow Compact – Effective June 22, 1999 - Within Tongue River Basin & Reservation
Tongue River	No	No water rights issued since 1995
Yellowstone River	Below Mouth w Bighorn River	Conservation District Water Reservation Water May be Available
Yellowstone River	Below Billings and between Billings and Livingston	FWP In-stream flow reservation may limit new appropriations
Youngs Creek	No-Basin Closure	Crow Compact – Effective June 22, 1999 - Within Tongue River Basin & Reservation
Shields River	Yes, Sometimes	No year round or full season irrigation water available, but high spring flows and other times of year have availability.
Yellowstone River	Yes, Sometimes	No every-year availability left, so would need the ability to turn off at a trigger flow or mitigate when lower flows. Subject to future perfection of water reservations.

Table VIII-1 indicates the following status of water availability in the Yellowstone Basin: the basin closure on Rock Creek for the irrigation season limits appropriations of surface water to exceptions including groundwater subject to 85-2-360, MCA. Compact closures limit appropriations in the Bighorn, Little Bighorn, Pryor and Rosebud sub-basins. Water may be available from conservation district reservations downstream of the mouth of the Bighorn River. No permits have been issued on the Powder River and Tongue River, and Big Porcupine Creek since 1995. New appropriations may be available from the Yellowstone above Billings. New appropriations may be possible at selected times including during high spring flows on the Shields River.

Changes in Use - Reallocation of Water to New Uses

The place of use, point of diversion, purpose of use, and place of storage are all elements of an existing water right that may be changed upon proof that the proposed change will not cause adverse effect to other water users. The Montana Water Use Act also includes special provisions for changes for aquifer recharge and mitigation, temporary changes, and temporary leases. These provisions provide water marketing opportunities along with the ability to permanently or temporarily reallocate water for future needs.

The reallocation of existing water rights to new uses will require (1) improved methods for calculating historical consumptive use and (2) expanded stream gaging to measure the available supply and evaluate physical and legal availability of water for appropriation.

DNRC calculates historical consumption use associated with pre-1973 water right claims from various sources of information. Historically irrigated acres are derived from water resource survey maps, historical aerial photography, and affidavits from water users. Consumptive water use is then calculated by applying standard engineering equations on crop water demands to county level agricultural statistics. Given the site specific nature of irrigation practices and crop water needs, the use of county level agricultural data may over estimate consumption in some cases and under estimate consumption in others.

More accurate methods of determining consumptive use are needed as competition increases for limited water supplies and the knowledge of irrigation practices used prior to 1973 fades with time. Advances in the development of computer modeling software to calculate water consumed by crops using commercially available information generated from NASA's Landsat Program provide an opportunity for Montana to bring a higher degree of accuracy to the water right change process.

WATER USE 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 that 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 to ensure that a proposed change will not adversely affect other water users on the source. Increases in the amount of consumption or changes in the pattern of use from the historic use of the water 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 flow is 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 effects 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 AND AQUIFER RECHARGE

In 2011, the Montana Legislature facilitated 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 provides existing water users with the opportunity to market water while preserving their existing use.

TEMPORARY CHANGES

A water user may temporarily change a water right with DNRC approval pursuant to § 85-2-407 and 408, MCA. A temporary change may be approved for up to 10 years, with an opportunity to renew for 10 more years, and there is no limit on the number of renewals. The water user must identify the proposed change and how long it will be needed, as well as meet other criteria. If granted, the temporarily changed appropriation has the same priority date as the existing water right. Unlike a permanent change, temporary changes automatically revert to the original use at the expiration of the term. Therefore, they can be an effective method for providing water for temporary or short term needs.

Temporary changes and leases pursuant to § 85-2-408 and 436, MCA, provide the only means for a private water user and FWP to maintain or enhance instream flows to benefit the fishery resource.

TEMPORARY LEASES

In 2013, the Montana Legislature adopted §85-2-427, MCA, which provides the opportunity to lease a water right for 2 years within a 10-year period. While the volume of water that may be leased is limited to 180 acre-feet per year, the statute provides a simplified and faster procedure. This new statutory tool enables water to be temporarily reallocated to serve short term needs and provides existing water users with the opportunity to market water while preserving their existing use.

SALVAGE WATER

Pursuant to §85-2-419, MCA, a water user may retain the right to the beneficial use of water “salvaged” by implementing a water-saving method. However, the right to the use of salvage water for any purpose or in any place other than that associated with the original water right requires prior authorization by the DNRC and is subject to the change provisions of §85-2-402, MCA. In practice, water users have had limited success in proving the existence of salvaged water and lack of adverse effect to other water users due to the fact that many efficiency improvements result in increased consumption or otherwise alter conditions on the source relied upon by other water users.

VOLUNTARY WATER MANAGEMENT

Ever since the early years of water use in Montana, demands for water focused primarily on agriculture and mining. In times of shortage, it was not uncommon for neighbors to ration water. In the 1970s and 1980s river recreation came into its own in Montana. Interest in whitewater kayaking, rafting and fishing grew with increasing popularity in the headwaters of the river basins of Montana.

By June of 1994, the last vestigial population of riverine Arctic grayling in the lower 48 states was threatened by high water temperatures and dewatering in the upper reaches of the Big Hole River near the town of Wisdom. At the urging of instream flow advocates, then Governor Marc Racicot directed Montana Fish, Wildlife, and Parks to monitor the flow status of the river day to day and report back to his office through the drought advisory committee. Instantaneous discharge records of U.S. Geological Survey Records from July 6, 1994, indicate that not only was the Big Hole River fishery in jeopardy of a fish-kill, but in headwaters tributaries throughout Western and Central Montana.

With the prospect of the Arctic grayling being listed under the federal Endangered Species Act development of an accord between the Big Hole water users, the U.S. Fish and Wildlife Service and the state became necessary. With temperatures rising and stream flows dropping, tension and acrimony erupted between the agricultural and instream flow advocates. Fisheries in rivers such as the Jefferson, Ruby, Beaverhead, and Gallatin east of the Continental Divide, and the Blackfoot, Bitterroot, and Rock Creek west of the Divide were reaching critically high day-time water temperatures and low flows as well, putting dwindling populations of bull trout and Westslope cutthroat trout as well as brook, rainbow and brown trout in jeopardy.

In the wake of 1994, conservation districts, water user groups, fishing guides and outfitters, and other instream advocacy groups called for collaboration among the interests. Irrigators wanted science and tools to better manage water instead of negative publicity or criticism for the legal use their water right. While the relationship between the interests could at times become adversarial they also had much in common: they both wanted local businesses to thrive; both wanted more information on the behavior of threatened and endangered species; both were eager to learn more about the local hydrology of their river source; they wanted water rights to be respected, and they wanted fisheries to be respected and lost habitat restored.

From the mid-1990s onward there was slow but steady progress on conservation. In 1993, the Governor’s Drought Advisory Committee received over $1 million from the U.S. Bureau of Reclamation’s (USBR) Emergency Drought Relief Act of 1991. USBR also provided assistance through its Agri-Met (Agricultural – Meteorological) field stations for scientific irrigation scheduling; the purchase of water for threatened and endangered species; conjunctive use wells to take pressure off of dwindling surface water supplies; irrigation canal lining to reduce seepage; stock water provided from USBR storage projects; fish ladders; head-gates and other control structures, stream gages critical for managing chronically dewatered stream reaches, and well-drilling for small town municipal water supplies. The Future Fisheries Program provided restoration funding for riparian habitat benefitting fisheries as well.

As the 2000s wore on and impacts of the drought carried over into succeeding years, water users worked even harder to stretch water supplies. Further investigation of local water supplies revealed that if a group of irrigators formed an informal alliance they could satisfy their regular right because it was a matter of *timing* their diversions of water. Some groups hired a professional to calculate just how much water each irrigator in a tributary basin would need for a particular crop. When the flows got very low the users apportioned precious water supplies and shared the sacrifice by cutting back on diversions to take pressure off of the fishery. Outfitters stepped-up in return by agreeing to limit guiding hours per day, using barbless hooks, and not playing

fish too long. The Department of Fish, Wildlife and Parks participated by placing restrictions on the hours in a day that fishing was allowed.

By 2008, there were over 40 watershed groups across the state formed by conservation districts, irrigation districts, canal companies, and instream flow advocacy groups like Trout Unlimited. With assistance from state and federal scientists, and local knowledge of water availability, the groups began a knowledge sharing period where the Montana Watershed Coordination Council hosted workshops for group coordinators and other interested parties.

The once ad hoc groups now have their own sophisticated water management and drought plans. And they celebrate their hard work and success with community events like golf matches on their hayfields, noxious weed pulling, barbecues, and fundraisers for worthy causes such as restoration of Trumpeter swans or Arctic grayling. With advances in climatological forecasting, improved water delivery systems, and tools such as automated mountain snow water stations and stream gauges, the groups are better able to manage their shortages autonomously. And since those dreadful water years of the 2000s they remain vigilant, never failing to meet year-round to discuss and revise their flow plans on a regular basis no matter how good the mountain snowpack and water supply outlook may be.

Basins with Hydrology that Could Potentially Support New Storage

The hydrology of streams in Montana, particularly in mountainous areas, might be suitable for new traditional storage because much of the annual flow volume in Montana is produced during the relatively short spring-runoff period. Water is potentially available for storage during runoff when water supply conditions meet or exceed median conditions and where existing storage capacity is small relative to the total volumes of water produced annually in the watershed.

Table V-1 lists existing storage reservoirs in the Montana and Wyoming portions of the Yellowstone River Basin. Collectively these projects have the capacity to store approximately 3.5 million acre-feet of water, or roughly one-third of the annual outflow of the Yellowstone River where it exits the state. While this suggests additional water might be physically available on the main stem and larger tributaries during spring runoff, legal availability is questionable due to existing water rights for storage, irrigation and instream flow, and downstream states' entitlements to water. Most eastern Montana prairie streams do not produce large water yields and are therefore not good candidates for traditional water storage.

Water might be available to store in the basin during the wettest years or even moderately wet years; however, a new reservoir might not be viable if it is not able to store water during a sequence of dry years. Furthermore, storage water rights for existing reservoirs may impose a potentially significant constraint on the feasibility of new traditional storage. Streams where high spring flow could be considered available based on stream flow and local water rights, might affect the ability of downstream reservoirs to store water.

The potential for storage on Yellowstone River Compact tributaries in Montana (Clarks Fork Yellowstone, Big Horn, Tongue and Powder River) is limited by the lack of suitable dam sites, environmental concerns, and legal and physical availability of water to store. A good example is the Allenspur Dam site located upstream from Livingston at the entrance to the Paradise valley. While the dam site appears ideal, the reservoir pool would flood the Paradise valley and the site itself has significant geotechnical stability problems with the potential west abutment adjoining a large active landslide.

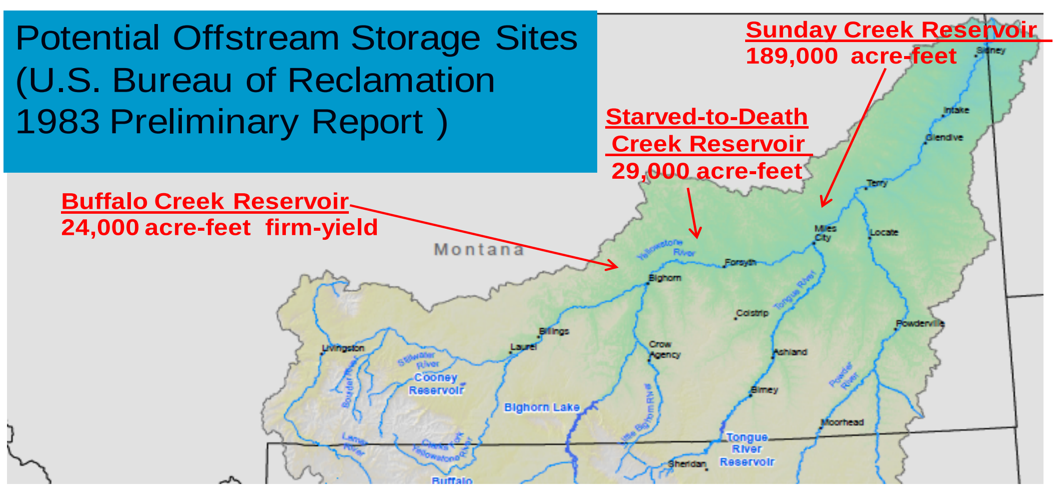
The four main tributaries to the Yellowstone River in Montana originate in the headwater of Wyoming and are subject to the provisions of the Yellowstone River Compact; any new storage projects in Montana would carry

very junior priority dates and be subject to call by senior storage rights and water uses in Wyoming. Wyoming is actively pursuing additional storage in Clear Creek, a tributary to the Powder River, and has repeatedly attempted to develop new storage on the Middle Fork Powder River--an issue that forms the basis of part of Montana's litigation with Wyoming in the U.S. Supreme Court.

The Yellowstone Water Reservations do provide water rights for three off-stream storage projects located mid-basin and north of the Yellowstone River (Figure VIII-1). A 1983 U.S. Bureau of Reclamation preliminary report estimated the following firm-yields (i.e. the amount delivered every year) for the three projects: Buffalo Creek Reservoir (near Bighorn confluence with main stem) could provide 24,000 acre-feet; Starved-to-Death Creek Reservoir (north east of Forsyth) could provide 29,000 acre- feet; and Sunday Creek Reservoir (north of Miles City) 189,000 acre-feet—the latter project would involve importing water from the lower Missouri basin. These projects would be very expensive to build. For example, new storage projects typically provide water at a cost of $100 to $1000 per acre-foot.

Another alternative might be to enlarge an existing storage facility to accommodate a greater volume of water. Some facilities may have been potentially undersized when constructed, and based on the hydrology of their basins could store additional water if structural capacity was increased. For example Tongue River Reservoir was capacity enlarged, when Tongue River Dam was rehabilitated in 1999 (to repair flood damage to the spillway caused by the flood of 1978), by 20,000 acre-feet; this cost $91 million (2014 dollars) or $1,600 per acre foot.

Figure VIII-1 Potential offstream storage sites with DNRC Water Reservations.



Feasibility and Constraints on Natural Storage & Retention

Floodplains with healthy riparian areas act to slow runoff and promote groundwater recharge; effectively storing water and releasing it slowly back to the surface water system. In this way, these natural systems fill a role similar to traditional reservoirs. The natural storage and retention benefits of these systems can be maintained and potentially enhanced by limiting the encroachment of urban development and 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 western Montana and the large watersheds of eastern Montana have been substantially altered by recharge from irrigation canals and the practice of flood irrigation. Significant volumes of water from irrigation conveyance and application practices are stored in alluvial aquifers and naturally released to support late season streamflow. Water users in these watersheds have grown dependent on these late season flows. However, aquifer recharge is a consequence of the primary beneficial use of the water.

Existing irrigation infrastructure provides ready means for augmenting the recharge of shallow groundwater systems. In some areas it may be feasible to run water through these systems outside of the normal irrigation season for the purpose of recharging shallow groundwater aquifers. This activity 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 by diverting unallocated flows into constructed wetlands or retention basins. The feasibility of an artificial 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 store.

IX. Findings and Recommendations

The complete recommendations from the Yellowstone Basin Advisory Council (YBAC) are set forth below. These recommendations were developed by the YBAC with input from the public, and local, state and federal resource managers. These recommendations are intended to advise DNRC with respect to Yellowstone water issues as it develops the State Water Plan and reflect the outcome of the 2015 MWSI water planning process (see Yellowstone Basin Planning Methodology in Chapter II).

Drought Readiness

Numerous extended dry periods are documented in the Yellowstone hydrologic record. Water availability and drought preparedness are motivating factors in any water resource sustainability strategy. Many tools and policies are available, including conservation, to assist with effective water allocation that maintains economic viability and preserves resource values during drought (see Water Information, Watershed Planning, and Water Administration).

Goal: *Provide sufficient information, and legal and administrative capacity to minimize adverse impacts during times of water scarcity.*

Objectives: (desired conditions)

A. Support and expand Montana's existing drought readiness efforts at local levels.

1. Expand the capability of the Governor's Drought and Water Supply Committee through implementation of information systems to support drought monitoring and availability of water information to water users and watershed groups for purposes of watershed planning.
2. Strengthen support and funding for programs, including Montana university and college programs--including the Montana Climate Office--involved in drought monitoring and forecasting;
3. Establish a statewide task force to coordinate water and climate information in an effort to eliminate duplication.
4. Develop adequate funding sources and incentives for mitigation of drought impacts for all water users.

B. Strengthen existing policies and statutes necessary for effective management of water resources.

1. Recommend changes, if necessary, to statutes and DNRC policies regarding water planning and management to improve the availability and distribution of water during droughts.
2. Recommend changes, if necessary, to statutes and DNRC policies that encourage conservation of water for all water uses and provide incentives for implementation of conservation measures.

C. <u>Provide tools (policies and legislation) for temporary water-supply management during extended droughts</u>. (The implementation items below would require assurances that the water-right holders' original entitlement and priority date remain unaffected, once the temporary use terminates):

1. Explore the feasibility of water banks.
2. During a declared drought emergency, develop water-use permits under an expedited process—drought permits would be limited to replacement of water not available under a permanent water right.
3. Develop temporary emergency water-use permits that include changes in type of use (including instream flow), place of use or point of diversion of an existing water right.

Water Information

The adequacy of existing water information, along with its availability, and ease of access to water users, water managers and the public is an issue. Sufficient water data needs to be collected and made available so that all relevant water information pertaining to a water body can be readily accessed and used to make informed decisions.

Goal: *Provide sufficient water information to efficiently and legally administer water rights, and promote an integrated approach to water resource management.*

Objective(s): (desired conditions)

A. Education and Outreach. Provide adequate education and outreach to ensure water user understanding of Montana water right law, hydrologic principles, water commissioner competency, and uniform enforcement of water right decrees.

1. Prepare an Education and Outreach Plan that examines the existing programs and curriculum offered by DNRC and the Montana Watercourse for water-related training and education to determine the need for and costs associated with expanding these programs.

B. Water Information System. Improve Montana's Water Information System to allow better access to water supply and availability information and promote an integrated approach to water resource management.

1. Upgrade the accuracy of Montana's Spatial Data Infrastructure (MSDI) Hydrography Framework Layer for purposes of organizing and distributing water information such as:
    a. Dam and reservoir mapping,
    b. Aquatic habitat information,
    c. Water right diversions,
    d. Water quality data and discharge permits,
    e. Wetlands data,
    f. Floodplains, Riparian Zones and Channel Migration Zones.
2. Invest in analytical tools that provide basic hydrologic information on which to base management decisions by:
    a. Conducting a Yellowstone River Basin Water Availability Assessment using a water availability model with updated software and inputs based on known factors such as decrees, compacts, the Yellowstone water reservations, historic stream gauge records, and updated water use estimates to determine the effect of increased water use and climate variability on Yellowstone water users, and
    b. Continuing development of StreamStats - an interactive, Web-based map application for providing streamflow statistics, such as the 100-year flood and the 7-day, 10-year low flow on streams and rivers with limited hydrologic information.

Integrated Water Quality and Quantity Management

Water use and water quality are linked. Every use of water affects its quality and as water consumption increases or the characteristics of the supply change, new and alternative uses can be affected. Water quality is an important issue in all areas of the Yellowstone River basin and influences beneficial uses.

Goal: *The desired condition is one in which current and future water use and water quality are balanced in the water administrative and regulatory framework*.

Objectives: (desired conditions)

A. State Management of Water Quality in Water Quantity Allocation. DNRC and DEQ should determine the best administrative and organizational procedures to assure coordination and carrying out current law and regulations related to:

1. Changes in water quality that would adversely affect the ability of an existing appropriator to exercise his/her water right.
2. Changes in water quality that would make a water body unfit for supporting beneficial uses.
3. Changes in the wetland and riparian conditions necessary to sustain water quality.
4. Changes in water quality or quantity that would inhibit the ability of existing discharge permit holders to satisfy effluent limitations.
5. Maintain consideration of current and future flow in authorizing point source discharges.
6. Continue assessment of state waters for flow-related, beneficial use impairments.
7. Provide financial and technical support for activities designed to restore water quality in waters that currently do not support their beneficial uses.

B. Support Activities and Programs to Benefit Both Water Quantity and Water Quality.

1. Maintain funding for improving and protecting water quality using best management practices at all levels of implementation. Promote Integrated Water Resource Management by improving coordination among state and federal agencies, tribes, local watershed groups, and the public.

Water Administration and Beneficial Use

Enabling fairness under Montana's water law is a significant issue in the Yellowstone Basin. Uncertainty is created by the large number of unused claims in the DNRC water rights system and senior users are sometimes unable to meet their water right due to misappropriation by other users. Any strategy to meet future water demand and put water to beneficial use needs to include examination of Montana's water right system so as to identify opportunities to maximize administrative efficiency and ensure proper monitoring and enforcement of water rights.

Goal: *Improve the existing water right administrative system to ensure water allocation according to established priority and identify unallocated water to satisfy current and future claims.*

Objectives: (desired conditions)

A. Water Right Adjudication Process.

1. Maintain necessary water right claims examination services provided by the DNRC in support of the Montana Water Court.

B. Abandoned (Orphan) Water Rights.

1. Provide clarity through legislation to the administrative and water court processes used to identify abandoned and overstated water rights.

C. Water Right Enforcement. Ensure proper measurement and distribution of water under decree.

2. Enact legislation that allows water right holders to permanently establish enforcement projects through an administrative process, in addition to the legal process (filing suit in district court.)

3. Enact legislation that grants DNRC authority to directly enforce against illegal water use, including the imposition of penalties substantial enough to discourage such use.
4. Develop a method for disseminating information related to illegal water use complaints.
5. Maintain a water rights change process that requires applicants to accurately identify and describe historic use.

D. Measurement, Monitoring and Assessment. Require measurement and increase monitoring so that it is sufficient to understand water supply and use, enforce water right decrees and compacts, and to better understand the relationship between water quality and quantity.

1. Maintain the existing stream gauge network operated by the USGS for key main stem and tributary gauges via the USGS/DNRC Cooperative Agreement Program.
2. Institute a telemetered (real-time) stream gauge program operated by DNRC/MBMG.
3. Strengthen the capability to conduct an inventory of consumptive and non-consumptive uses.
   a. Develop the capability to measure agricultural water use using remote sensing, compare results of pilot studies to previous methods, and evaluate the overall cost-effectiveness of using remote sensing to measure water use.
   b. Require all users to measure at or near the point of diversion from the river or stream.
4. Provide assistance to water users to measure water at or near the point of diversion from a stream.
   a. Offer a tax credit for the cost of installation.
   b. Expand the DNRC Irrigation Development Program to provide grant dollars to pay costs.
   c. Facilitate the installation of measurement devices on development of Renewable Resource Grant applications for large volume ditches.
5. Knowing that these recommendations will incur costs, encourage multiple party collaborations and partnerships that yield creative funding mechanisms to pay for them.

Watershed Planning

Many water resource problems are watershed-specific and their solution requires a collaborative stakeholder approach within small- to medium-sized watersheds within the Yellowstone River basin, while other issues require a basin-wide approach. The need for planning and technical services, and access to information to develop and implement watershed plans, is expected to increase as demand for water increases. Existing funding mechanisms and personnel to support locally-led watershed planning are presently insufficient to meet current and projected demand.

Goal: *Establish a collaborative problem-solving approach to watershed planning resource management.*

Objectives: (desired conditions)

A. Resolve Basin-Wide Water Management Issues. Increase interaction and communication between water users, watershed groups, technical specialists, policy-makers, and water management agencies at all levels of government.

1. Continue to fund a basin-wide stakeholder group (such as the Yellowstone BAC) The purpose of the BAC would be to review progress on recommendations developed during the 2013/2014 biennium, advise DNRC on future water resource management priorities, and serve as a forum on basin-wide water-related issues.

2. Expand the scope of this group to include water quality, instream flow, groundwater, funding amounts and sources, and other related issues.

B. Resolve Watershed-Scale Water Management Issues. Increase interaction and communication between watershed stakeholders.

1. Use existing and potential funding mechanisms to provide technical and financial support to collaborative watershed groups in order to support recommendations in this plan.

Groundwater/Surface Water Nexus

Ground and surface water are linked, often in complex interactions that can only be characterized through site-specific long-term measurement and monitoring projects. Although groundwater usage in relation to surface water is relatively minor in the Yellowstone River basin, localized problems exist, particularly in areas impacted by land use changes or conversion from flood to sprinkler irrigation.

Goal: *Better manage water resources (rivers, streams, lakes, aquifers, wetlands, riparian zones, etc.) in the Yellowstone River basin by obtaining information on surface water and groundwater sufficient to determine the potential effects of existing and future land use changes and drought, especially in aquifers and surface waters that are necessary to sustain beneficial uses.*

Objectives: (desired conditions)

A. Groundwater Measurement, Monitoring and Assessment. Obtain information sufficient to understand the potential consequences of land use change on ground and surface water resources.

1. Continue and, if necessary, expand the Montana Bureau of Mines and Geology groundwater monitoring and assessment programs.

B. Groundwater/Surface Water Interaction. Obtain information sufficient to understand the localized effects of groundwater/surface water interaction.

1. Establish a surface water assessment program jointly operated by DNRC and MBMG to investigate the interaction between groundwater and surface water at sub-basin scales.
2. The legislature should review and make any changes in statutes necessary to optimize use of surface water and groundwater resources.

C. Groundwater Conservation. Conserve groundwater resources in the Yellowstone River basin.

1. Encourage local jurisdictions (i.e. counties, cities and conservation districts) to identify the hydrologic effects of land use change.
2. Encourage landowners to reduce the amount of discharge from uncontrolled flowing wells in the lower Yellowstone and Powder River basins by proper winterization and installation of discharge control valves using a combination of DNRC-Conservation and Resource Development Division (CARDD), private grant funds, NRCS grant funds, and landowner in-kind services to install and operate.

Instream Flow Maintenance

Despite the lack of on-stream main stem storage reservoirs, the natural hydrology of the Yellowstone River has been significantly altered by present-day levels of development. Instream flow maintenance pertains to maintenance of a stream’s complete hydrologic regime. Maintenance of instream flows is a significant issue, not only on the main stem Yellowstone River and its larger tributaries, but also on smaller tributaries necessary for the functionality of the river system.

Goal: *Provide sufficient protection for instream flows within the prior appropriation framework to maintain aquatic ecology and for other values, such as recreation and aesthetics.*

Objectives: (desired conditions):

A. Provide specific “Change in Use” mechanisms that allow and incentivize users to assist in maintaining instream flows without compromising their ability to use water or fundamental water right. Usage of existing tools, such as temporary and permanent changes to instream flow, should be expanded and promoted to protect instream flows within the prior appropriation framework.

B. Improve recognition of the surface water/groundwater nexus. Recognizing the hydrologic interconnectivity between groundwater and surface water, and affirming the need to protect instream flows, the waters of the basin should be better managed as an interconnected system.

C. Impact of future water development. In the context of existing and future development demands, the ability of the existing water supply to meet instream flow rights must be considered in approving new water developments (see B.2.a - water availability assessment under Water Information).

D. Yellowstone Water Reservation Review Process. The water reservation review process established by the Board of Natural Resources and Conservation (now DNRC) should be implemented for all Yellowstone Water Reservations to determine whether or not the objectives of the individual reservations are being met and, if necessary, whether individual reservants have prepared water conservation and drought contingency plans as required by the Order of the Board.

E. Maintain an intact hydrologic regime. Manage river and stream flows in ways that avoid threats to the long-term health or survival of native species and implement practices that maintain or restore indigenous ecological communities, processes and functions.

F. Reservoir Management. Procedures to maintain instream flows should be developed with attention to the effects of new and existing dams on sediment transport, water temperature and the hydrologic regime. Strategies for water releases and sediment management should minimize the negative effects to riverine processes below the dam.

G. Longitudinal Connectivity. Procedures to maintain instream flows should recognize and document the importance of connectivity within stream systems, and efforts should be made to restore connectivity where needed by modifying in-channel barriers.

H. Drought Planning. Drought planning efforts within the Yellowstone Basin must include the development of legal, physical, and management mechanisms or plans to implement water conservation during drought periods to protect essential instream flows.

I. Channel Maintenance. Recognizing lateral migration processes as important, efforts to maintain instream flows should include provisions for retaining or reestablishing alluvial channel form and function with associated biological communities.

J. Continued Study and Monitoring. As the science of instream flow advances and more field data is collected, evaluation of instream flow needs must be ongoing. Monitoring riverine resource responses to instream flow prescriptions is a fundamental component of effective instream flow maintenance.

Water Storage

Water storage is an important part of integrated water management in the Yellowstone River Basin. However, traditional storage projects (dams and reservoirs) are expensive to plan, construct, manage, and maintain. In addition to construction of new storage, alternatives such as the prioritization of uses for water stored within

existing reservoirs, maintenance of storage facilities, and modification of existing projects are important tools to mitigate effects of water supply variability. Managing stream and wetland systems to enhance natural channel and floodplain storage can augment structural measures by reconnecting streams to their floodplain, protecting wetlands, and encouraging healthy riparian vegetation.

Goal: *Maintain existing storage projects and with the exception of the main stem Yellowstone River, develop new storage, including non-structural alternatives such as enhanced groundwater recharge, to improve seasonal and year-to-year availability of water for new and existing uses of water.*

Objectives: (desired conditions)

A. Prioritize New Projects. Affirm the use of criteria contained in the Montana Water Storage Prioritization Policy (MCA §85-1-704 (2)(a) through (2)(j)) as applied to the prioritization of new storage projects. Enhancing alluvial aquifer recharge via wetland and riparian zone improvement projects should also be considered as a means for reducing flow variability and maintaining the natural hydrologic regime for streams and rivers in the Yellowstone basin.

B. Maintain Existing Storage Projects. Affirm the use of criteria contained in the Montana Water Storage Prioritization Policy (MCA §85-1-704 (3)(a) through (3)(c)) as applied to setting priorities among storage rehabilitation projects.

C. Allocation of State Funds for Storage Projects. Affirm the use of criteria contained in the Montana Water Storage Prioritization Policy (MCA §85-1-704 (4)(a) through (4)(c)) as applied to setting budget priorities among new storage construction and rehabilitation projects.

D. Water Storage Financing. The State of Montana should focus resources on understanding, coordinating, and improving funding programs for water storage development, operation, maintenance, and rehabilitation.

Funding

The Legislature directed that DNRC update the State Water Plan. In order to implement the statewide water plan, funding is required.

Goal: *Identify current and potential funding sources*.

Objectives: (desired conditions)

A. Revenue Sources: Look for revenue from new and existing sources.

1. Look for revenue sources from all those who benefit from access to state water resources (including recreationists, irrigators, municipalities, water-rights holders, etc.)
2. Look for revenue from existing funding sources (such as the Resource Indemnity Trust and other programs for example.)

X. Glossary

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.

Groundwater – Any water beneath the land surface.[1]

Groundwater Recharge or Aquifer Recharge – Can refer both to the natural process of groundwater 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 groundwater 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 groundwater 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 that is 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.[3]

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 groundwater withdrawal, the surface water would be depleted by a rate equal to a rate of at least 30% of the groundwater 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.

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.*

XI. Photo Credits

COVER:

Upper Left—Paradise Valley, Upper Yellowstone River. (Courtesy of Larry Dodge)

Left Center—Fly fishing Upper Yellowstone River (Chuck Dalby, Montana DNRC)

Left Center—Rosebud State Park and Cartersville Diversion Dam at Forsyth (Chuck Dalby, Montana DNRC)

Bottom Left—Unit Coal Train near Forsyth (Chuck Dalby, Montana DNRC)

Upper Right—DNRC Hydrologist Mike Roberts and Water Commissioners, Charles Kepper and Charlie Gephart (Chuck Dalby, Montana DNRC)

Bottom Right—Yellowstone Basin State Water Plan Advisory Council Meeting (Chuck Dalby, Montana DNRC)

Figure IV-2 - Paradise Valley and Upper Yellowstone River south of Livingston, Montana (Montana Office of Tourism--Travel Montana)

Figure IV-24 - Little Bighorn River (Montana Office of Tourism--Travel Montana)

Figure IV- 31 - Upper Yellowstone River near Pine Creek at flood stage (Chuck Dalby Montana DNRC)

Figure V-3 - Cattle grazing near Big Timber Montana (Chuck Dalby Montana DNRC)

Figure V-4 - Unit coal train carries coal from Colstrip-area mines. (Chuck Dalby Montana DNRC)

Figure V-5 - Miles City municipal water tower and swimming pool Chuck Dalby Montana DNRC)

Figure V-10 - Gated-pipe, furrow irrigation in eastern Montana (Natural Resources Conservation Service)

Figure V-14 - Paradise Valley near Livingston, Montana showing inlet channel to Livingston Ditch Diversion (center) and Depuy’s Spring Creek (center right) Chuck Dalby Montana DNRC)

Figure V-15 - Fly-fishing is an important recreational use of water in the upper and middle planning sub-basins (Montana Office of Tourism--Travel Montana)

Figure V-18 - Tongue River Dam and Reservoir after dam and spillway rehabilitation. (Montana DNRC)

Figure VII-2 - Wheel-line sprinkler irrigation in the Yellowstone River Basin. (Natural Resources Resource Conservation Service)

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XIII. List of Figures


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