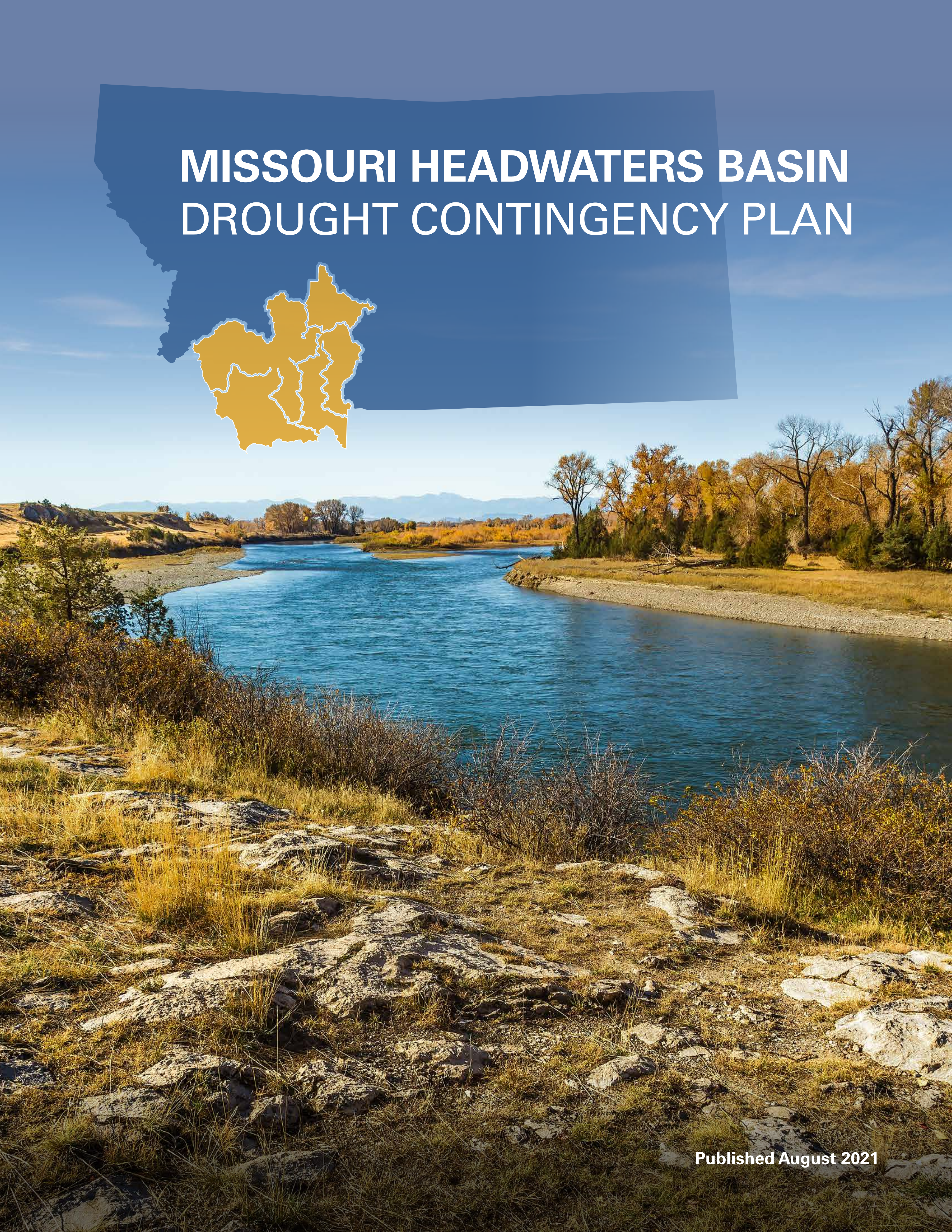
MISSOURI HEADWATERS BASIN
DROUGHT CONTINGENCY PLAN



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Back Cover: Big Sky Watershed AmeriCorps members are helping build community resilience in the Upper Missouri Basin. *Jon Catton photo.*

EXECUTIVE SUMMARY

In 2013, Montana state agencies and federal partners initiated targeted water assessment and drought planning activities in the Upper Missouri Basin that have informed and provided the foundation for this drought contingency plan. Through this Basin focused planning process, it is our hope to create an innovative, collaborative model that demonstrates how to build capacity for locally-led water planning, how to leverage and integrate multiple research studies and resources and finally, how to build partnerships that ensure effective basin wide water management strategies for a more sustainable water future. Successful planning cannot happen in a silo, but rather build upon and integrate the work and expertise of a variety of sources to weave a solid foundation. In many ways, this plan provides the basis for planning at the local level and connects resources both laterally and vertically to create a network of individuals, communities, and agencies that monitor conditions, recognize drought vulnerabilities and have developed community based strategies to reduce drought impacts. This plan and planning network provide the framework to reduce those risks through proactive planning and increasing the adaptative capacity beginning with the community and connecting throughout the Missouri Headwaters Basin (MHB).

SECTION 1: DROUGHT PLANNING HISTORY

In the semi-arid western United States, access to plentiful clean water has always been a challenge. Early pioneers were drawn to Montana and the west with hopes of building a better life, often by settling the wild landscapes through crop cultivation and development of the water resources. Although it was always dry, successful settlers were able to divert surface water for irrigation and "proving up" their homesteads. But streams in southwest Montana depend on seasonal precipitation, primarily winter snowpack, with some summer rainfall. In the valleys of the Missouri Headwaters Basin (MHB), annual precipitation can be as low as 8". With the dependence on seasonal water supplies, droughts are frequent in the region as a slight variation in precipitation can stress the system. Locals often state, "We are only 2 weeks away from a drought." Drought planning has always been important for water management in Montana, but now more than ever, stressors are challenging us to be better prepared and proactive in developing strategies to satisfy competing demands for a very limited resource. Drought planning in the Missouri Headwaters Basin, (sometimes referred to as the Upper Missouri Basin (UMB)), has been focused at the local watershed level and created drought response plans focused on maintaining stream flows. The foundation of this plan is to increase and support drought planning within the HUC 8 watersheds, identify common vulnerabilities and risks, and then create a network of informed stakeholders that are able to implement local projects and collectively reduce the incidence and severity of drought impacts for the Headwaters region. This plan covers the entire Headwaters sub-basin and unites the individual, localized, watershed planning efforts into a Missouri Headwaters Basin Plan. The impetus for developing the Basin Plan is a culmination of the multitude of assessment and planning efforts that have been occurring in the basin for several years. The selection of the Basin as a Demonstration Project for the National Drought Resilience Partnership focused on the Missouri Headwaters Basin in 2014.

MULTIPLE PLANNING EFFORTS

While the focus area for this plan is the Missouri Headwaters Basin in southwest Montana, it is directly linked and builds upon several other plans, including: 8 local watershed plans (HUC 8 watersheds), regional plans and assessments (Upper Missouri Basin Plan, BOR UMRB Impacts Assessment, Upper Missouri Basin Study), state plans (MT State Water Plan and Montana Climate Assessment) and even national planning efforts such as the National Drought Resilience Partnership. The following section provides a brief overview of the state and regional planning efforts and activities that have provided much of the information and basis for developing the integrated MHB Drought Contingency Plan. The individual HUC 8 watershed/tributary planning efforts will be covered later in the document but the tributary watersheds are outlined in the figure below. For planning purposes, zoom in from the state level, to the major basin level, to the sub-basin and down to the HUC 8 tributary watersheds, and consider each level nestled within the larger region to create continuity that allows greater connection across the landscape. For clarification, there is some confusion in using the term "Upper Missouri" depending on the point of reference or purpose. Nationally the Upper Missouri River Basin may be considered the region north and west of the confluence with the Platte River, which flows through the states of Montana, Wyoming, North and South Dakota. For planning purposes within the state of Montana, the Upper Missouri Basin is the area upstream of the confluence with the Marias River, North and East of Fort Benton, MT. This Drought Contingency Plan is focused on the very beginning of the Missouri River, the Headwaters (sub) Basin which begins in the southwest corner of Montana, adjacent to Yellowstone National Park and the Idaho border and flows north from there. (See Figures 1 and 2.)

FIGURE 1 Missouri Headwaters Map – *USFWS*

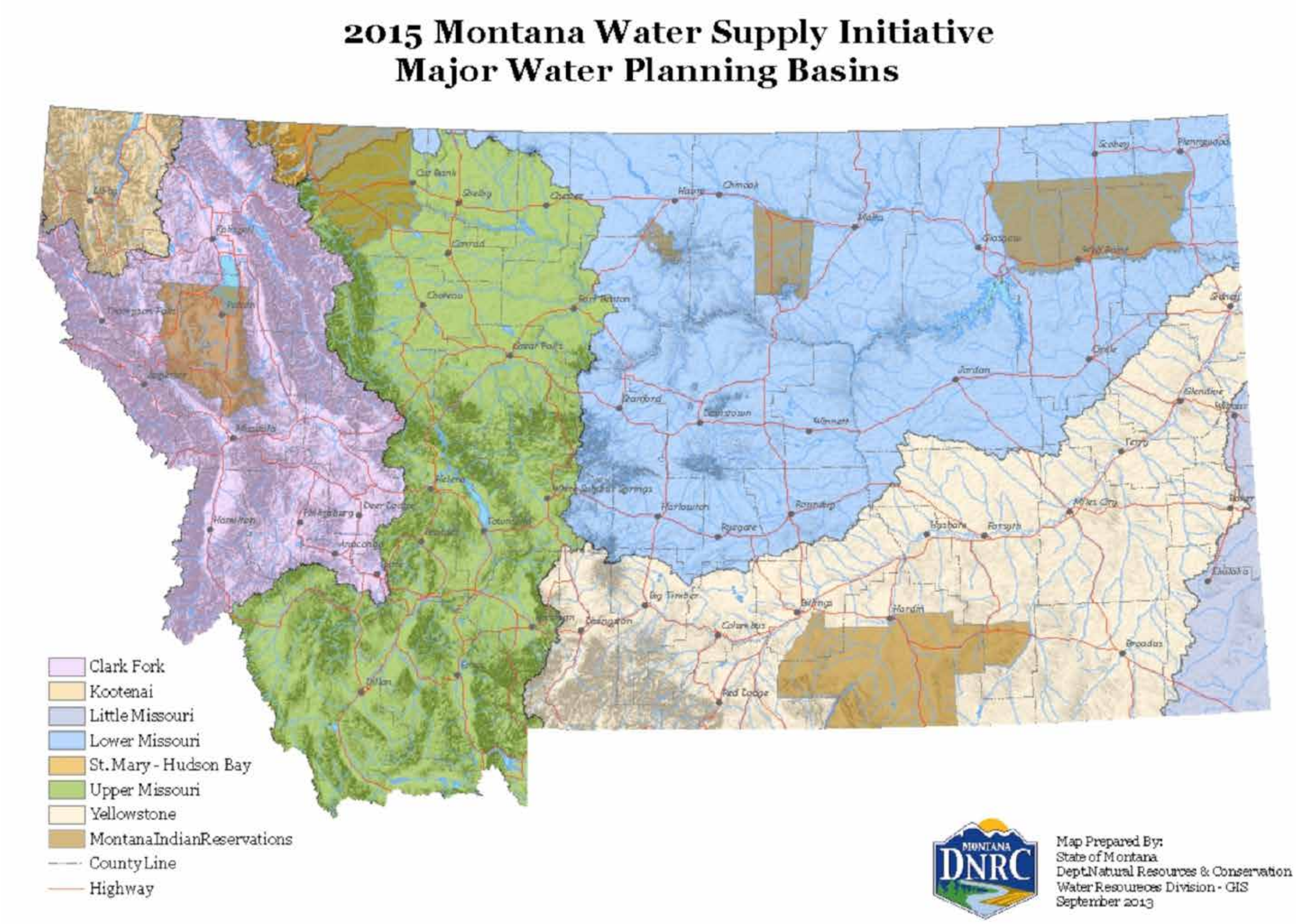

FIGURE 2 2015 Montana Water Supply Initiative Major Water Planning Basins – *DNRC*

UPPER MISSOURI RIVER BASIN PLAN AND 2015 MT STATE WATER PLAN

(MT Department of Natural Resources and Conservation)

In 2014, as a precursor to updating the Montana State Water plan, Montana DNRC conducted the Montana Water Supply Initiative, which completed Basin plans for each of the 4 major basins in Montana; the Clark Fork/Kootenai Rivers, the Yellowstone River, the Lower Missouri and the Upper Missouri River Basin. The Upper Missouri Basin in Montana contains the Headwaters region in SW Montana north along the rocky mountain front to the confluence with the Marias River in north central MT. The Upper Missouri Basin in Montana can be divided into 3 regions or sub-basins, the Headwaters, Central and Northern sub-basins. For the State Water planning process each major river Basin had a multi-stakeholder Basin Advisory Council (BAC) with appointed representatives from each of the primary water user groups (agricultural irrigation, hydropower, mining, recreation, conservation, municipal and industry) selected from within the individual Basins. The BACs spent many months hearing from experts and identifying key water issues that were ascribed to topic areas for the region. The Upper Missouri BAC developed over 62 recommendations to address the many water resource issues identified during the process. Each of the Basins created a detailed rich, stand-alone document for guiding the management of the Basin's water resources and the 18 month long process provided the major findings and foundation for the development of the comprehensive 2015 Montana State Water Plan.

As excerpted below, the Montana State Water Plan clearly identifies coordinated drought planning as an important recommendation. The recommendation also highlights the importance of building upon a collaborative approach from within small to medium sized watersheds, which is one of the reasons that we have focused this effort on the HUC 8 tributary watersheds that form the Missouri Headwaters Basin (MHB).

Support and Expand Existing Drought Preparedness and Planning Efforts

Drought preparedness requires a collaborative approach within small- to medium-sized watersheds. Working together, water users and water management agencies can develop adaptive management strategies that can yield benefits to water supply, fisheries, and water quality. Adaptive management also requires effective coordination between state and federal agencies responsible for managing water supply, water quality, fisheries, and drought and water supply forecasting. Successful adaptive management is facilitated by ready access to information about stream flow, water rights, water quality and aquatic habitat.

- *Support the development of drought management plans in small to medium size watersheds.*
- *Assess potential threats to the state's water supply and economy resulting from extended periods of drought and increased climate variability by partnering with appropriate state and federal agencies to conduct one climate risk assessment pilot study in one of the four planning basins.*

UPPER MISSOURI RIVER BASIN IMPACTS ASSESSMENT: RISK AND RELIABILITY ASSESSMENT

FIGURE 3 Overview of Upper Missouri River Basin Impacts Assessment and Complementary Missouri Headwaters Basin Study.

(Bureau of Reclamation)

In 2019 the Bureau of Reclamation completed the Basin Impacts Assessment for the entire Upper Missouri Basin in Montana, from the headwaters to Fort Peck Reservoir. Both the Impacts Assessment and the subsequent Basin Study were conducted for a larger region, however the information and data for the Headwaters region provided the foundation for the Missouri Headwaters Drought Resilience Plan. The Impacts Assessment was completed primarily by Reclamation, but both the Basin Study and this Drought Resilience Plan are collaborative efforts conducted jointly by Reclamation and the MT Department of Natural Resources and Conservation (MT DNRC).

The Impacts Assessment considered water supplies, demands, and management risks to help quantify imbalances between water supplies and demands under current and projected future conditions in the Upper Missouri Basin study area. The Basin Study incorporated the data generated from the Impact Assessment to identify and evaluate potential adaptation strategies to address historical and projected imbalances. Projections of future water supplies and demands, as well as paleohydrology information, helped assess drought vulnerabilities and inform drought response actions for this Drought Resilience Plan. Relationships between the Impacts Assessment and Basin Study are illustrated schematically in Figure 3, as excerpted from the Basin Study Report.

MISSOURI HEADWATERS BASIN STUDY

(BOR-DNRC Cooperative Study with USGS)

The Basin Study report builds on the foundational information on historic and future water supplies developed in the Impact Assessment to identify and evaluate adaptation strategies for alleviating future impacts to water resources in the basin.

The purpose of the Basin Study was to develop and evaluate strategies for addressing water resource challenges under a range of potential future conditions, including population growth, changes in future water supply and demand related to climate change, and supply conditions based on a broad range of historical conditions drawn from paleohydrology analysis.

Specifically, the Basin Study had the following objectives:

- Assess current and projected future water supply and demand within the basin, and water supply risks relating to changing climate conditions
- Simulate system operations under scenarios representing the distant past, the recent past, and the future
- Incorporate existing information related to groundwater sources in high-demand areas, such as the Gallatin and Beaverhead valleys
- Analyze the water and power infrastructure performance and operations under hydrology scenarios (paleohydrology and future) and future growth scenarios using the Upper Missouri RiverWare planning model,
- Conduct outreach to involve stakeholders in the development of the adaptation strategies and trade-off analysis
- Model adaptive management strategies for the basin and analyze the potential of these strategies
- Conduct trade-off analyses of the identified strategies and develop findings and recommendations

The Basin Study was conducted for many reasons, including that the 2015 MT Water Plan Update directed MT DNRC to plan for future management of water in the Missouri Headwaters given population and economic growth and changing water supplies and demands. Also, previous studies, including the Reclamation Impacts Assessment, identified potential changes in future conditions that highlight the need for a long-term planning study. Specifically, a future warming trend and changes in spring runoff volume and timing are projected. Evapotranspiration and associated crop demand as well as reservoir evaporation are also projected to increase with warming temperatures. Projected changes in runoff timing in the snowmelt dominated watersheds of the Missouri Headwaters are likely to have a significant effect on the timing of streamflow for irrigation and municipal demands. Projected changes in runoff timing and volume are also likely to impact the amount and timing of water available for fish, wildlife, and recreation, which have become an important component of the region's economy. Reclamation's storage reservoirs in the study area may play an even larger role in meeting the region's water management objectives in the future with warmer temperatures increasing demand for stored water. Finally, because much of the Missouri Headwaters area is closed to most new surface water appropriation, groundwater may be increasingly used to meet water demands in the future. However, new groundwater uses are complicated by the interaction between surface and groundwater. Aquifer recharge, return flow patterns, and discharge from aquifers to streams are likely to change with increasing demands and changes in irrigation methodologies.

The datasets, models and information generated for both the Impacts Assessment and Basin Study provide a foundation for future investigations and implementation of strategies. The partnerships developed between Reclamation, MT DNRC and local stakeholders have helped form the foundation for this Drought Contingency Plan.

FIGURE 4 Missouri Headwaters Basin Study location map.

NATIONAL DROUGHT RESILIENCE PARTNERSHIP MONTANA DEMONSTRATION PROJECT

(NDRP)

As part of President Obama's Climate Action Plan, the Administration launched a multi-agency National Drought Resilience Partnership (NDRP) to provide federal support and coordination for communities seeking help to prepare for future droughts and address drought impacts. The NDRP is comprised of representatives from:

- US Dept of Agriculture (USDA),
- National Oceanic Atmospheric Administration (NOAA),
- Dept of the Interior,
- Assistant secretary of the Army for Civil Works,
- Environmental Protection Agency (EPA),
- Federal Emergency Management Agency (FEMA), and
- US Department of Energy

(See Appendix {{?}})

In 2014, Montana Governor Steve Bullock and NDRP representatives identified Montana's Upper Missouri River Basin as the location to demonstrate how NDRP might partner with the state to improve drought preparedness. The Missouri Headwaters Basin in southwest Montana was selected as one of two national Drought Resilience pilots by the National Drought Resilience Partnership (NDRP) to demonstrate collaborative efforts to build resilience. In Montana, NDRP agencies partnered with the MT DNRC to build pro-active drought resilience strategies in the region. The goal of the Missouri Headwaters Drought Resilience Demonstration project is to develop long-term drought resilience by demonstrating how improved drought planning, preparedness and mitigation outcomes can be achieved through enhanced coordination of state and federal agency resources. In Montana the NDRP is demonstrating how drought planning and resilience can be improved when the federal government coordinates and focuses its resources in support of local drought planning in the Missouri Headwaters basin and its tributary watersheds. In Montana the NDRP demonstration project was led primarily by MT DNRC and Region 8 EPA administrators and staff.

The Missouri Headwaters basin was selected as it represents diverse conditions where one or more federal agencies, state and local partnerships are already working with watershed communities to develop drought resilience. The basin boasts several actively engaged Conservation Districts, watershed and water user groups and non-governmental organizations (NGOs) that are already collaborating with key water users and stakeholders within their watersheds. The region also plays an important role in landscape connectivity in the northern Rockies, experiences frequent drought, and faces rapidly changing population and land use. Although local groups in the area recognized the need to prepare for drought, they lacked the human. financial and technical capacity to fully utilize innovative planning tools and implement solutions. Federal and State partners have tremendous resources for drought monitoring, forecasting, and early warning systems, but the information isn't always readily accessible to local planners and decision makers. The goal of the project is to connect these stakeholders and water users with the resources they need to predict, inventory, identify, and proactively plan to create community resilience in the face of prolonged drought or water shortages.

Many of the HUC 8 watersheds in the basin (Beaverhead, Big Hole, Ruby, Jefferson, Madison, Upper and Lower Gallatin and Red Rock Rivers and the Broadwater conservation district which covers the area between the headwaters confluence and Canyon Ferry Reservoir) each had at least part time watershed coordinators working locally on natural resource issues. Project partners (BOR, EPA, & DNRC) provided additional funding to place Big Sky Watershed AmeriCorps (BSWC) members to support drought planning capacity to these community-based watershed groups. Many of the coordinators were already engaged in some form of drought planning, but most did not have the skills or knowledge to embark on leading a community effort. The MT NDRP team coordinated with many partners including the National Drought Integrated Drought Information Center (NIDIS), National Drought Mitigation Center (NDMC), US Forest Service and the Science Nature and People Partnership (SNAPP) Ecodrought team, to launch a series of trainings, webinars, workshops and community outreach to collectively train each of the drought coordinators and their BSWC members. Additionally workshops were held to engage as many of the potential partners as possible in the project. The section below briefly outlines the many trainings and workshops over the course of this multi-year effort. (See Table 1.)

BUILDING DROUGHT EARLY WARNING CAPABILITY IN MONTANA WORKSHOP

Training for Resilience, March 2015

Through coordinated support of NOAA's National Integrated Drought Information System (NIDIS), MT DNRC, and the Environmental Protection Agency (EPA), the NDRP team hosted the first of several workshops to introduce the watershed drought coordinators to resources to begin to build a portfolio of knowledge and

DROUGHT TRAININGS, WORKSHOPS AND COMMUNITY OUTREACH

TITLE	2015	2016	2017	2018	2019
Building Drought Early Warning Workshop	■				
MT Drought Ready Communities Course		■			
BOR Drought Contingency Planning		■			
Train the Trainer Workshop		■			
Building Drought Resilience in the MHB Workshop					
MHB Study and Impacts Assessment Workshop					
Improving Drought Resilience/Forest to Valley Bottom, USFS Conference			■		
SNAPP EcoDrought Framework for Drought Planning			■		
UMH Basin Task Force meetings			■	■	■

TABLE 1 Drought Trainings, workshops and Community Outreach, 2015-2019

drought tools, and better prepare them for leading drought planning in their home watersheds. The workshop was designed to bring together watershed-based "teams" that could initiate conversations with their communities on preparing for future drought conditions. Workshop facilitators from NIDIS and the NDMC led the groups in a step-by-step drought planning process using tools, such as the Drought Impacts Reporter, the Drought Risk Atlas, and the Drought-Ready Communities guide to track conditions, identify triggers and work through potential conflicts between water users. The attendees included BSWC AmeriCorps members, watershed coordinators, state and local agencies, city planners, agricultural producers, land trusts, conservation districts, NGOs, hydrologists, and local federal partners. (See full report in Appendix {{?}})

MONTANA DROUGHT READY COMMUNITIES (ONLINE COURSE)

In the Spring of 2016, the drought coordinators participated in a multi session online course titled Montana Drought Ready Communities (see Appendix), led by the National Drought Mitigation Center (NDMC). The objective of the course was to provide the opportunity for the drought coordinators to work with national, state and local experts to develop approaches for drought in their communities. Instructors covered course materials during monthly two-hour interactive webinars. Homework assigned between the classes offered opportunities to assemble and review relevant information that was useful in the development of a local drought planning outline. Most importantly, these outlines were developed to help guide local coordinators in developing and initiating drought planning activities for their watersheds. (See full report in Appendix {{?}})

BUREAU OF RECLAMATION DROUGHT CONTINGENCY PLANNING

During the Summer of 2016, MT DNRC was awarded the Reclamation Drought Contingency Planning grant to develop this drought contingency plan for the Missouri Headwaters Basin. DNRC took a slightly different approach and used the funds to sub-award $20,000 to each of 8 community-based watershed groups that were already participating in the NDRP MT Drought Demonstration project. These funds were used to support the capacity for each of the local drought coordinators to lead drought planning in their home watersheds. Each of the individual watersheds has both similar and unique issues related to drought and water management, and they were all in different stages of preparedness to launch a focused effort. The individual reports reflect their unique challenges and approaches. As the individual efforts were underway, we continued to engage the coordinators in training and delivering more technical resources to support their planning, as well as creating a unified network of drought coordinators, each assessing their watershed community issues and vulnerabilities. We also convened the coordinators regularly to collectively identify and discuss vulnerabilities and challenges in their home watersheds and how those issues would be reflected in the Basin plan. The networking among the coordinators created opportunities to identify additional resources that would help each understand and better manage their own water management challenges. For example, the Jefferson River has stream flow triggers for their drought management plan, but they are the recipients of several upstream tributaries, including the Ruby, Beaverhead, Red Rock and Big Hole rivers. So as each river is managing for their own target flows, it is critical that they also understand the triggers and response mechanisms for their contributing streams. The effective implementation of the Missouri Headwaters Basin plan is based on the coordinated communication and understanding of each of the individual watersheds and the collective impacts for the Basin.

TRAIN THE TRAINERS WORKSHOP

September 2016, Bozeman, MT. The community drought coordinators, trainers and other partners met in Bozeman for a check in and refresher course on the Spring webinar series to review the tools and skills for leading drought planning in their communities. The intent was to "train the trainers", basically equipping each of the local drought coordinators with the tools and understanding on how to lead their community efforts. Presenters included professionals from NDMC, Wildlife Conservation Society, SNAPP Ecodrought team and the Center for Large Landscape Conservation. The presenters covered data, historic droughts, incorporating climate change, developing impacts and vulnerability assessments, and developing response and mitigation plans for their planning efforts.

MONTANA DROUGHT RESILIENCE PROJECT WORKSHOP

October 2016, all of Montana's NDRP partners (state and federal) and local watershed representatives (80+ attendees) convened in Dillon, Montana for 2 days to identify shared goals for developing drought preparedness plans and mitigation strategies. During this meeting and based on two previous meetings, the group drafted a workplan that identified objectives and implementation tasks toward building drought resilience for the Basin. The workplan is summarized and organized in three overarching goals:

1. Provide Tools for Drought Monitoring, Assessing and Forecasting
2. Develop Local and Regional Capacity to Plan for Drought
3. Implement Local Projects to Build Regional Drought Resilience

Within each of these broad goals, the workplan highlights objectives and implementation tasks to reach the overarching goal of coordinated landscape-wide drought resilience. While the workplan was developed for the NDRP MT Demonstration project, many of the goals and objectives have been implemented and are also foundational to the Drought Contingency Plan for the Basin. The workplan provided an achievable outline for building the community resilience model structure, which provides the basis for the Drought Contingency Plan. See Table 2.

KEY GOALS, OBJECTIVES, AND IMPLEMENTATION TASKS
GOAL 1: PROVIDE TOOLS FOR DROUGHT MONITORING, ASSESSING, AND FORECASTING
A. Develop a Drought Monitoring Network • Coordinate a monitoring network to support local and regional needs • Expand soil moisture monitoring • Expand streamflow monitoring to address data gaps • Expand precipitation monitoring (CoCORaHS)
B. Develop a Portal to Share Monitoring, Assessment and Forecasting Information Across the Network • Explore and compile existing data to create a central information portal on basin specific data accessible to all water users
GOAL 2: DEVELOP LOCAL AND REGIONAL CAPACITY TO PLAN FOR DROUGHT
A. Build and Engage Local Capacity for Drought Planning • Assure adequate staffing and operational needs • Provide consistent drought mitigation trainings and technical assistance
B. Increase Local Community Awareness of Drought and Supply Planning, Forecasting, and Mitigation • Inventory and assemble local community member lists and conduct awareness workshops • Develop creative communication and outreach tools to engage local leaders in the planning process • Develop a marketing or branding strategy for drought and the demonstration project
C. Provide the Tools and Technical Assistance to Help Local Groups Strategize and Develop Drought Plans • Monitor and identify risks, vulnerabilities and supply/demand triggers • Set systems in place to manage voluntary agreements
D. Connect Local Drought Plans at the Regional Scale • Review local plans and merge into a regional drought preparedness plan for the entire Basin • Explore agency drought plans
E. Develop a Regional Network to create a Streamlined Structure to Share Learning, Coordinate and Pursue funding opportunities and Deliver Resources across the Basin • Build a network/framework that unifies, coordinates and simplifies the delivery and sharing of resources.
GOAL 3: IMPLEMENT LOCAL PROJECTS TO BUILD REGIONAL DROUGHT RESILIENCE
A. Increase Water Conservation Measures • Work with municipalities in the Basin to develop water conservation campaigns and measures • Work with the farmers/ranchers in the Basin to implement water conservation and irrigation efficiency and delivery measures.
B. Ensure Riparian, Floodplain and Water Management Measures Are in Place • Inform the public of the value of riparian areas and floodplains for improved water holding capacities • Assess and improve natural storage capacity • Install off-stream stock water tanks to reduce impacts to riparian areas and facilitate upland grazing management • Consolidate and maintain points of diversion to improve efficiencies • Implement hybrid sprinkler/flood systems that transition as flows change
C. Ensure Upland Management Measures are in Place • Demonstrate integrated management on public lands, and collaborate to implement projects to protect water quantity and quality in the headwaters • Develop a suite of soil and upland health demonstration projects in the Missouri Headwaters • Explore the impacts of conifer expansion on water yield • Study, understand, and implement practices that improve soil health and moisture holding capacities.

TABLE 2 Montana Drought Resilience Project Key Goals, Objectives and Implementation Tasks

MISSOURI HEADWATERS BASIN STUDY AND IMPACTS ASSESSMENT WORKSHOP

December 2016, Helena, MT. Montana DNRC and Reclamation held a cooperative all-day workshop in Helena, MT to review progress and share information on the Impacts Assessment and the Upper Missouri Basin Study. The 35 participants included state and federal agencies, conservation organizations and drought coordinators. The workshop covered a variety of topics but was designed to review progress on the Impacts Assessment, discuss climate change impacts, integrating water supply and demand, outreach for the subsequent basin study, updates from partners and further opportunities for cross collaboration.

IMPROVING DROUGHT RESILIENCE: FOREST FLOOR TO VALLEY BOTTOM, USFS REGION 1 WORKSHOP

March 2017, Choteau, MT. As part of the national focus on drought resilience, DNRC worked with the US Forest Service Region 1 to host a drought resilience workshop in the Upper Missouri portion of the Crown of the Continent region. The workshop was held in collaboration with NDRP partners, local tribes, and the Crown Managers Partnership. Over 100 participants, including many landowners from the Upper Missouri basin attended the 2- day workshop. The focus of the workshop was to provide awareness and understanding of vulnerabilities of drought across key resources from the forest floor to the valley bottom. Presentations focused on forest health, rangeland and riparian resources and how drought impacts the different ecosystems from top to bottom. The primary objectives were to provide a forum to collaborate among agencies and private landowners on drought management and consider adaptation strategies and actions that can be applied to management of private, state, tribal and federal lands. (See full report in Appendix {{?}})

SNAPP ECODROUGHT FRAMEWORK WORKSHOP

July 2017, Bozeman, MT. The Science Nature and People Partnership (SNAPP) EcoDrought working group, worked with partners in the UMH to develop new methods of understanding and incorporating ecological drought into the conversation and assessment phases of drought planning. They hosted a small workshop to test their innovative method and structure for incorporating ecological drought into comprehensive vulnerability assessments and planning. The team invited the drought coordinators to work through the new methodology as an aid to drought planning, with emphasis on identifying ecosystem vulnerabilities and impacts. Participants developed new ways of categorizing ecosystem services, how they are distributed across the Missouri Headwaters landscape and began to identify strategies for reducing ecosystem vulnerabilities in ways that had not been previously considered. The SNAPP team has published 2 scientific journal articles based on their work with drought coordinators identifying ecosystem vulnerabilities in the Upper Missouri Basin. More details are provided in the Vulnerability Assessment section.

UPPER MISSOURI HEADWATERS BASIN TASK FORCE MEETING

November 2017, Bozeman, MT, DNRC, EPA and Reclamation cohosted a meeting of all the partners working on drought planning, assessments, and monitoring in the Basin. More than 115 participants attended, including each of the local drought coordinators and key stakeholders from their watersheds. It was an opportunity for everyone to share, learn from one another and collaborate on all work, assessments, studies and innovative tools related to drought planning in the region. During the afternoon session the SNAPP eco-drought team led the participants in in-depth discussions focusing on the key ecosystems, Forests, Range and Riparian areas to identify ecological vulnerabilities given potential drought. More details and outcomes are provided in the vulnerability assessment section. Throughout the entire process, the watershed drought coordinators, Task Force members and key partners met regularly to discuss progress at the local level and share learning experiences, resources and techniques for engaging their communities in drought planning. These regular meetings were vital to strengthen networking, discuss vulnerabilities and develop potential adaptation and mitigation strategies.

Snowpack levels in the Missouri Headwaters Basin, like those across the western U.S., have declined 15-30 percent over the past century. *Jon Catton photo.*

SECTION 2: WATERSHED BACKGROUND

GEOGRAPHY

The Missouri Headwaters Basin, located in the southwest corner of Montana, adjacent to Yellowstone National Park includes the three forks of the Missouri River-the Jefferson, Madison and Gallatin Rivers and their tributaries, the Red Rock, Beaverhead, Big Hole, Ruby and Boulder Rivers. The actual headwater stream of the Missouri is located high in the Centennial mountains at Brower's Spring, which flows into Hellroaring Creek and then into the Red Rock River in the Centennial Valley, eventually flowing into the Beaverhead River which continues north to join the Ruby and Big Hole Rivers for the confluence of the Jefferson River. The Jefferson continues to flow north and eventually meets the Madison and Gallatin tributaries at Three Forks, Montana forming the Missouri River. The Missouri continues to wind its way north to Canyon Ferry Reservoir, a Bureau of Reclamation project. For purposes of this drought plan, we considered the entire area from Brower's Spring to Canyon Ferry. The total watershed or drainage area is over 14,700 square miles producing an annual flow of about 4,000,000 acre-feet of water. Each tributary watershed and contribution toward the total volume produced is listed below in Table 3 with specific details in the following sections.

WATERSHED	DRAINAGE AREA (square miles)	APPROXIMATE MEDIAN ANNUAL VOLUME OF WATER PRODUCED (acre-feet)
Gallatin River	1,800	946,000
Madison River	2.510	1,310,000
Ruby River	965	216,000
Beaverhead-Red Rock Rivers	3,620	592,000
Big Hole River	2,500	817,000
Jefferson River*	2,445*	120,000
Missouri River headwater Total (to Toston)	**14,700**	**4,000,000**

TABLE 3 Tributary watershed contributions toward total volume produced in the Missouri River Headwaters Basin

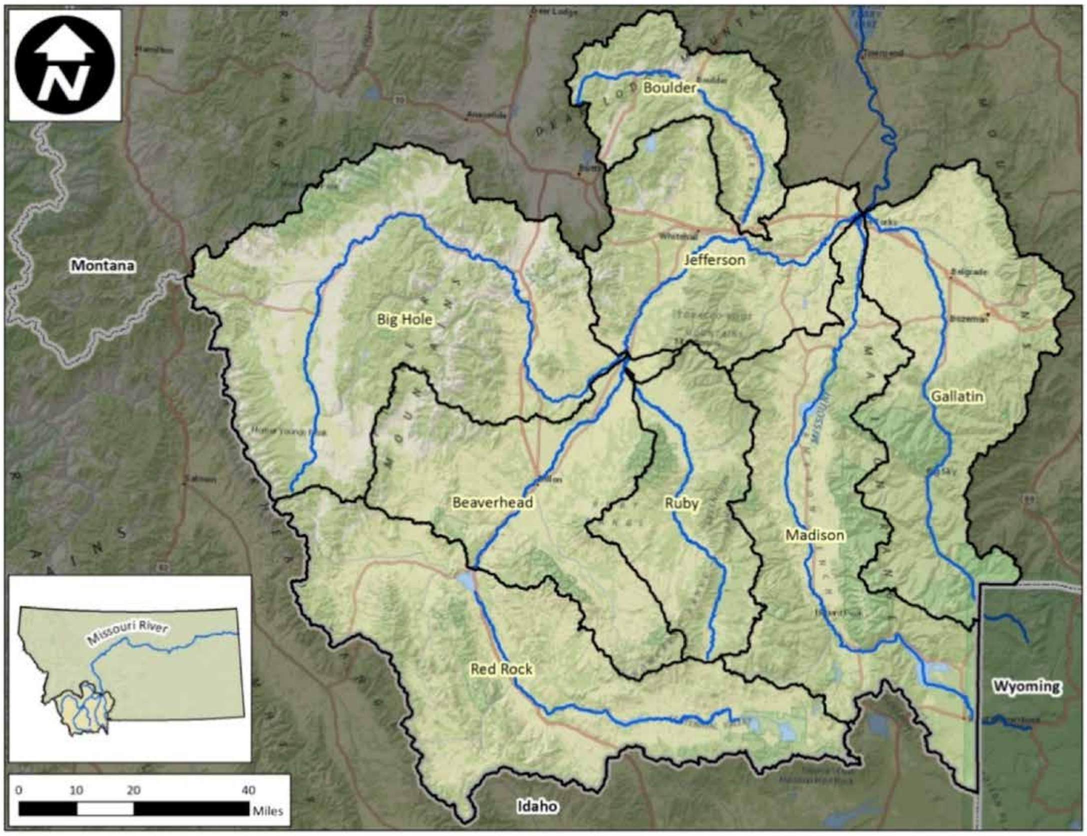

FIGURE 5 Missouri Headwaters Basin

LAND USE AND DEMOGRAPHY

The area is characterized by a series of high mountain ranges and broad river valleys and is predominantly rural wide-open spaces, with more livestock than people scattered among the small ranching communities. Madison and Beaverhead Counties have a total population of 18,172 inhabiting almost 6 million acres (larger than Connecticut and Delaware combined) and only have one (Beaverhead) or no (Madison) traditional traffic signals. However, directly north of Yellowstone NP, the Gallatin valley and the city of Bozeman (63.6% population change from 2000-2018) are one of the fastest growing areas in the US, which is pushing exurban sprawl out to the smaller communities and converting much of the surrounding agricultural lands to development. In the Upper Gallatin River area (closer to Yellowstone) the Big Sky area is home to several exclusive ski and vacation resort developments, namely Big Sky, Yellowstone Club, Moonlight Basin and Spanish Peaks. The rapidly developing alpine area is sandwiched between 2 wilderness areas, spans across 2 counties and drains into 2 different watersheds, creating an abundance of unique water management challenges.

The Upper Missouri Basin is dominated by federal ownership (50.3%), followed by private lands covering the next 42.7% (See Table 4). Historically the area was important for many tribes as common hunting and fishing grounds, however, there aren't any federally recognized tribal reservations in the region today. The Big Hole National Battlefield is an historic site located outside of Wisdom in the Big Hole watershed. Although the area is primarily rural agricultural, typified by mountains with river valleys, it is becoming increasingly popular for tourism and recreational opportunities. People come from all over the world to fly fish the blue-ribbon streams of the region, hunt wild game, hike in the backcountry and ski in the many ski resorts. Thus, the local economies are equally dependent on having water for irrigation, habitat and recreation. Severe, prolonged drought has the potential to devastate the communities in the basin.

Many community-based conservation organizations are located in the rural communities across the basin. These organizations may vary in their structure and style, from non-profit watershed groups, to quasi-governmental conservation districts, but they each work collaboratively with diverse stakeholders to address their unique natural resource issues in their watersheds. They provide a natural conduit to community leaders and decision makers and have valued relationships based within the community as well as a good understanding of the many natural resource challenges.

LAND OWNERSHIP total acres	Beaverhead County, MT	Madison County, MT	Gallatin County, MT	Jefferson County, MT	Broadwater County, MT	Combined County Region
Total Area	3,566,679	2,306,267	1,685,617	1,062,024	792,389	9,412,976
Private Lands	1,110,666	1,080,470	886,074	470,427	473,737	4,021,374
Federal Lands	2,100,619	1,061,098	734,614	555,087	278,881	4,730,299
BLM	667,229	250,049	7,242	92,541	71,308	1,088,369
Forest Service	1,376,974	810,362	662,623	462,546	188,476	3,500,981
Other Federal	56,416	687	64,749	0	19,097	140,949
Tribal Lands	0	0	0	0	0	0
State, City, County, Other	355,395	164,699	64,926	36,510	39,769	661,299
Percent of Total						
Private Lands	31.1%	46.8%	52.6%	44.3%	59.8%	42.7%
Federal Lands	58.9%	46.0%	43.6%	52.3%	35.2%	50.3%
BLM	18.7%	10.8%	0.4%	8.7%	9.0%	11.6%
Forest Service	38.6%	35.1%	39.3%	43.6%	23.8%	37.2%
Other Federal	1.6%	0.0%	3.8%	0.0%	2.4%	1.5%
Tribal Lands	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
State, City, County, Other	10.0%	7.1%	3.9%	3.4%	5.0%	7.0%

TABLE 4 Headwaters Economics Bureau of Land Management Socioeconomic Profile Tool

WATER RESOURCES AND USE SECTORS

Most streamflow in the headwaters originates in the mountain ranges that rise to as high as 11,000 feet which receive substantial amounts of rain and snow. Valley bottoms, on the other hand, are typically much drier and range in elevation from 4,000 to 6,000 feet. Streamflow patterns in the headwaters area are snowmelt dominated, typically peaking during late May or early to mid-June, which coincides with peak mountain snowmelt and spring rains. The hydrograph (Figure 6) represents typical streamflow scenarios in the MHB.

Water resources in the Missouri Headwaters Basin are mostly a snowpack dependent system, a portion of which ultimately will be realized as surface water flow. Mountain snowpack generally begins to accumulate in the late fall, with the snowpack peak typically occurring near the end of April or beginning of May. Snow accumulation and snow water equivalents are tracked in near real time through the Natural Resources Conservation Service's SNOTEL monitoring network. Some of this accumulated snow melts in May, but most of the snow melts during June. Most of the rest will evaporate or be transpired by vegetation, or percolate, at least temporarily, to shallow groundwater aquifers. Average annual precipitation ranges from about 10 inches in the drier valleys and prairies to about 80 inches at the highest elevations, with the overall average being about 19 inches. Precipitation in the Upper Missouri River Basin generally increases with elevation. Higher elevations and mountains are water producing areas, where precipitation is often higher than the amount of water the plants need to grow. Lower elevation valleys are water deficit areas, where the precipitation is usually less than evaporation and evapotranspiration. Agricultural irrigation accounts for the largest amount of water use in the basin, followed by reservoir evaporation and Municipal and Industrial uses accounting for a very small percentage.

IRRIGATION:

Irrigation diversions account for the largest percentage of water use in Montana, and MHB is no different. The agricultural valleys are dominated by pasture and hay production to support livestock operations. Historically irrigators relied on flood irrigation techniques, but many of the producers are converting to sprinkler and center pivots for irrigating their fields. There are several reservoirs in the Basin with the primary objective of storing water to meet downstream irrigation demands. These irrigation reservoirs are either state or federal projects and include; Ruby Reservoir (MT DNRC-32,000 AF), Clark Canyon Reservoir (USBR-99,287 AF) which supplies water to the East Bench Unit of 56,000 acres, and Lima Reservoir.

Table 5 is extracted from the Basin Study and provides more detail on irrigation water use, and specifically BOR projects in the Headwaters Basin.

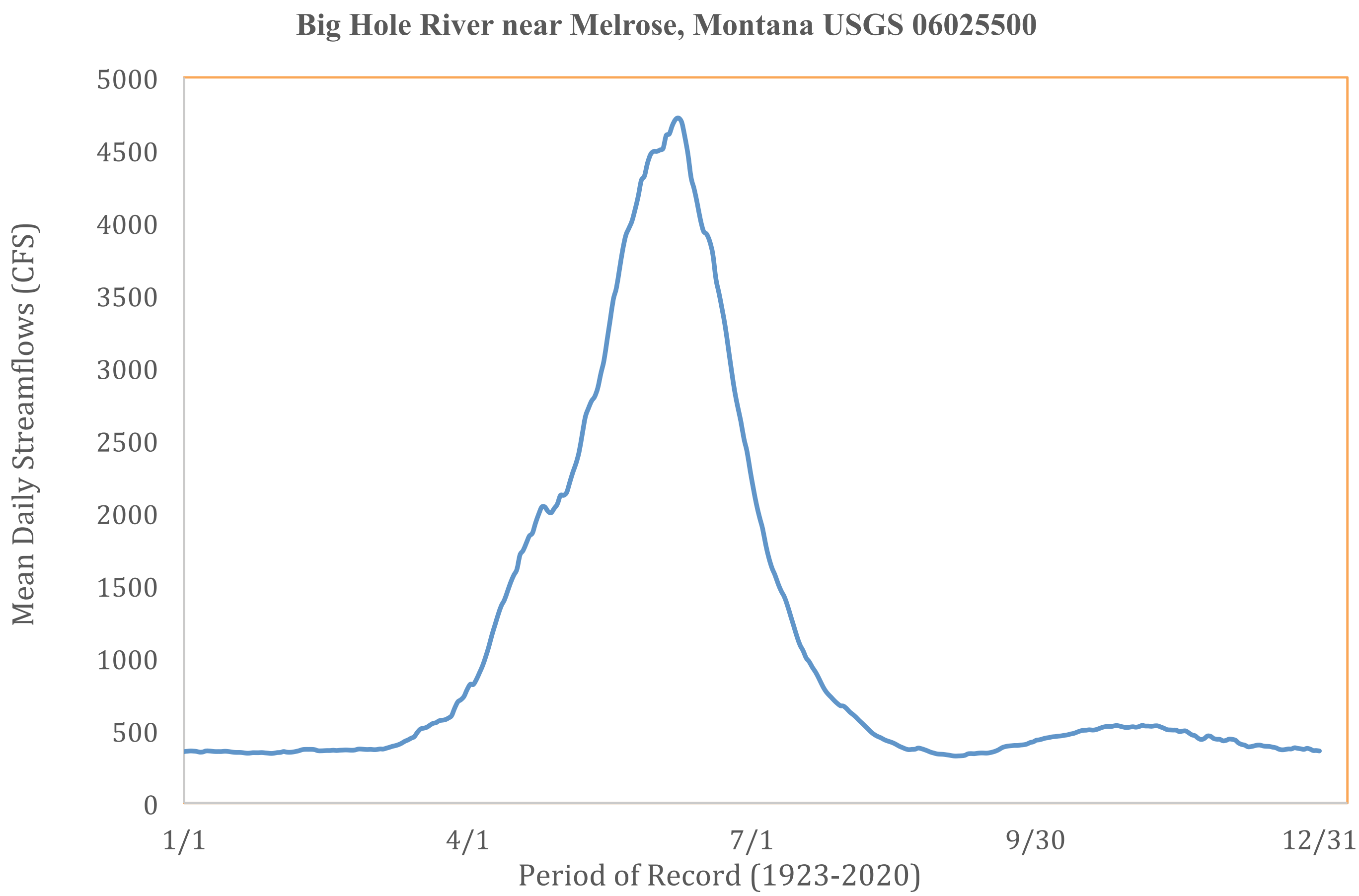

FIGURE 6 Big Hole River Mean Daily Streamflows *(CFS)*

IRRIGATED ACRES		
HUC-8	Name	Acres
10020001	Red Rock	65,491
10020002	Beaverhead	77,566
10020003	Ruby	37,590
10020004	Big Hole	150,396
10020005	Jefferson	51,402
10020006	Boulder	10,530
10020007	Madison	33,392
10020008	Gallatin	102,208
10030101	Upper Missouri	67,789
	Total	**596,364**

PROJECT/PROGRAM UNIT		PURPOSE AND WATER SOURCE
Pick-Sloan Missouri Basin Program (P-SMBP)	East Bench Unit	Irrigation deliveries for 56,000 acres from Clark Canyon Reservoir on the Beaverhead River
	Crow Creek Pump Unit	Irrigation delivveries for 23,400 acres from the Mainstem Missouri River near Toston
	Canyon Ferry Unit	Multi-purpose deliveries from the Mainstem Missouri River near Canyon Ferry Reservoir hydropower generation

TABLE 5 Irrigation water use and BOR projects in the Headwaters Basin

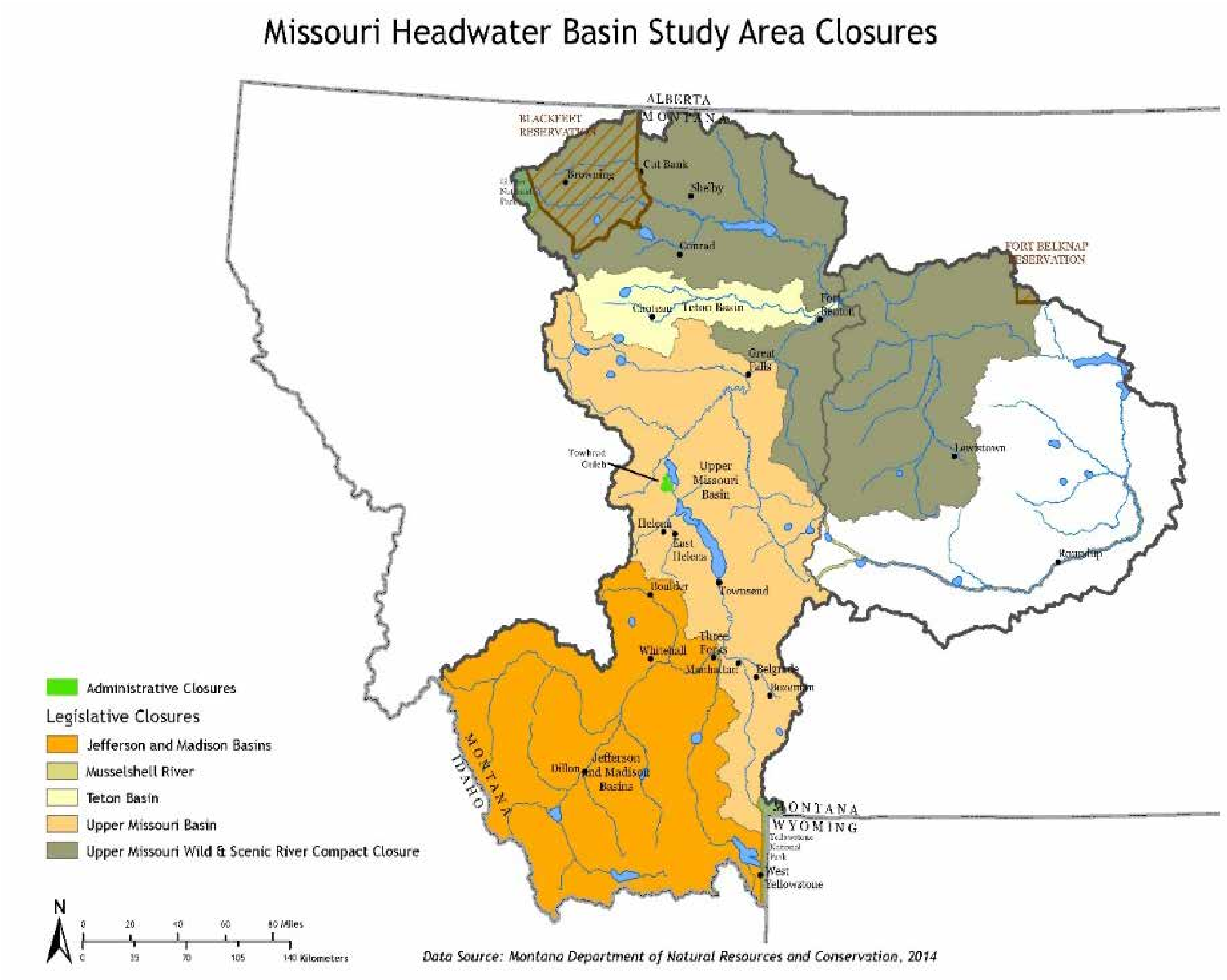

FIGURE 7 Missouri Headwater Basin Study Area Closures

HYDROPOWER:
Canyon Ferry hydropower operations are primarily governed by the Missouri River Coordination Agreement (Reclamation and Montana Power Company 1972). NorthWestern Energy projects are also operated in accordance with the Missouri River Coordination Agreement, and in accordance with provisions and requirements specified in the Federal Energy Regulatory Commission (FERC) license for the Missouri-Madison Project (Hydropower Reform Coalition and River Management Society 2014). Objectives of the Missouri River Coordination Agreement include:

- Maximize power generation benefits for both Canyon Ferry and the downstream NorthWestern Energy hydropower facilities
- Provide irrigation and municipal and industrial (M&I) water supply
- Provide flows for fish, wildlife, and recreational use
- Manage flows for flood control
- Prevent ice-jam flooding above Canyon Ferry

During median and drier years, the larger dams have the capacity and water rights to generate electricity with the entire flow of the river during all months in most years except May and June. The water rights for some of the larger-capacity hydropower facilities have relatively early priority dates and can effectively limit the flow available for junior water rights holders. A Montana DNRC water availability analysis (Montana DNRC 1981) found that water might only be available for storage, diversion, and use during spring runoff in 60 percent of years. The study further found that due to the senior water rights of some larger-capacity hydropower facilities, water is seldom available for storage, diversion, and use after August 9 until early spring of the next year.

RECREATION:
The area is world renowned for fly fishing, boating and winter snow sports which are all dependent on consistent streamflows, ample snowfall and sufficient lake and reservoir levels to support aquatic ecosystems and river, lake and mountain activities. There are many destination fly fishing lodges as well as fly rod manufacturing businesses located in the

Basin. The fishing industry is extremely vulnerable to variable streamflow conditions as MT Fish Wildlife and Parks will often enact fishing restrictions when water levels and temperatures exceed certain limits. These limits are designated to protect and reduce the stress on the fish populations. However, when one river is closed to fishing, then the fishing pressure often increases on adjacent streams as guides try to find sites for their tourist clients. The area is also very popular for whitewater rafting, canoeing, and kayaking which clearly are streamflow dependent. There is an abundance of high mountain lakes and several state or federally managed reservoirs in the basin that also support water- based recreation opportunities. Constructed systems include: Hebgen and Ennis Lakes, Hyalite, Lima, Ruby, Clark Canyon, Willow Creek and Canyon Ferry Reservoirs. Many of the reservoirs have cabin and homesites along the shores, often with water level dependent boat ramps, adding complexity to water level management strategies. Winter sports include alpine and Nordic skiing and snowmobiling. The region boasts five alpine resorts (Big Sky, Moonlight Basin, Yellowstone Club, Bridger and Maverick) ski areas and two cross country areas (Lone Mountain and Bohart Ranch). The area is becoming much more popular with out of state visitors to participate in one of the well- known recreational opportunities that are water and snowpack dependent.

MUNICIPAL AND DOMESTIC:

As previously indicated the area is primarily rural agriculture, with a few concentrated areas of population. Most notably the City of Bozeman is one of the fastest growing communities in the nation. Several years ago, the City of Bozeman recognized that if they continued to grow and use water at their current rate, they would run out of water in 2030. This prompted the City to develop and adopt a Drought Management Plan in 2017 that lays out strategies to reduce demands and create a tiered system of increasing costs as water supplies drop. The City continues to develop and refine their plan to accommodate unprecedented growth and development. The resort communities in the Big Sky area are also especially vulnerable to water shortages as they experience pulses of vacationers during the winter and summer seasons. The water challenges in Big Sky occur at both ends of the spectrum, meaning maintaining adequate supply and disposing of treated wastewater. The Gallatin River Task Force initiated community discussions known as the Big Sky Sustainable Solutions Forum to try and collaboratively address the complicated water issues in the region and improve their water regional water security. Most of the other communities in the basin rely on either surface or groundwater to meet their municipal demands. The communities that rely on surface water are more vulnerable to changing conditions and water supply availability, especially in light of climate change and changing or reduced snowpack.

WATER RIGHT CONSTRAINTS:

Closed Basin: Water planning in the region has become increasingly important as the Headwaters Basin is closed to almost all new surface water right appropriations. The closures are defined either administratively (by the legislature) or as a controlled groundwater area, such as the Yellowstone CGA to protect the natural thermal features of Yellowstone. Montana manages surface and ground water conjunctively as a single resource, so getting a new water right permit in the Basin is extremely difficult and requires extensive proof that a new groundwater permit will not adversely affect surface water resources. Additionally, there are existing downstream uses, such as hydropower or instream flow rights, that constrain the development of new upstream appropriations. As the climate changes and the hydrographs begin to shift it will be increasingly important to develop adaptation strategies to capture snowpack runoff to provide water for longer, hotter growing seasons.

Instream Flow: The Montana Department of Fish, Wildlife and Parks (Montana DFWP) holds instream flow rights within the Upper Missouri River Basin to provide flows for fish, wildlife, and aquatic habitat. The major rights fall under the following two general categories:

1) Murphy Rights. In 1969, the Montana legislature enacted a law allowing the Montana Fish and Game Commission to file for water rights on the unappropriated waters to maintain stream flows necessary for the preservation of fish and wildlife habitat (Section 89-901 (2), RCM 1947). In the Missouri Headwaters, Montana DFWP filed for Murphy Rights for the Madison, Gallatin, and West Gallatin. These rights have December 1970 priority dates.
2) Water Reservations. In 1992, Montana DFWP was granted water reservations for minimum instream flows to protect fisheries, aquatic habitat, and associated recreational values. In the Missouri River Headwaters, instream reservations generally were based on the amount of instream flow required to protect riffle habitat in the streams as quantified by the Wetted Perimeter Inflection Point method (Montana DFWP, 1989). By §85-2-316 Montana Code Annotated (MCA) these rights were limited by statute to one-half the average annual flow for gaged streams.

These locations and instream flow rates are summarized in Table 6. In extremely dry years, FWP will make a call on the water right holders that are junior (post 1970) to the Murphy rights on the upstream tributaries. (See details in Appendix {{?}}, extracted from the *Upper Missouri River Basin Water Plan, 2014,* Fish, Wildlife and Parks instream flow rights by sub-basin.)

RIVER BASIN	LOCATION	FLOW (CFS)	PERIOD
Beaverhead River Basin	Upper Beaverhead River	200	annual
	Lower Beaverhead River	200	annual
	Red Rock River	60	annual
Big Hole River Basin	Lower Big Hole River	573	annual
	Upper Big Hole River	160	annual
Gallatin River Basin	Upper Gallatin River	800	May 16 - Jul 15
	Upper Gallatin River	400	Jul 16 - May 15
	East Gallatin River	170	annual
	Lower Gallatin River	947	May 1 - May 15
	Lower Gallatin River	1278	May 16 - May 31
	Lower Gallatin River	1500	Jun 1 - Jun 15
	Lower Gallatin River	1176	Jun 16 - Jun 30
	Lower Gallatin River	850	Jul 1 - Aug 31
	Lower Gallatin River	800	Sep 1 - Apr 30
Jefferson River Basin	Upper Jefferson River	50	annual
	Lower Jefferson River	1095.5	annual
	Boulder River	47	annual
Madison River Basin	Madison River below Ennis Lake	825	annual
	Madison River below Ennis Lake	1200	Jan 1 - May 31
	Madison River below Ennis Lake	1500	Jun 1 - Jun 30
	Madison River below Ennis Lake	1423	Jul 1 - Jul 15
	Madison River below Ennis Lake	1300	Jul 16- Dec 31
Missouri River Mainstem	Upper Missouri River	1500	Jan 1 - Jan 31
	Upper Missouri River	3000	Feb 1 - May 15
	Upper Missouri River	4000	May 16 - Jun 30
	Upper Missouri River	3816	Jul 1 - Jul 15
	Upper Missouri River	1500	Jul 16 - Sep 14
	Upper Missouri River	3000	Sep 15 - Dec 31
Ruby River Basin	Ruby River below Reservoir	40	annual
	Ruby River near mouth	40	annual

TABLE 6 Tributary Watershed Flow and Period

Watershed-restoration practitioners discuss initiatives to reconnect the Ruby River with its floodplain to recharge wetlands and shallow aquifers so more water remains in the watershed for the hot summer months. *Jon Catton photo.*

SECTION 3: TRIBUTARY WATERSHEDS

The tributary watersheds each have their own set of physical and demographic characteristics, so the following section describes each of the watersheds for a better understanding of the individual issues.

The information is excerpted and compiled from the individual watershed planning efforts and the 2014 Upper Missouri River Basin Water Plan.

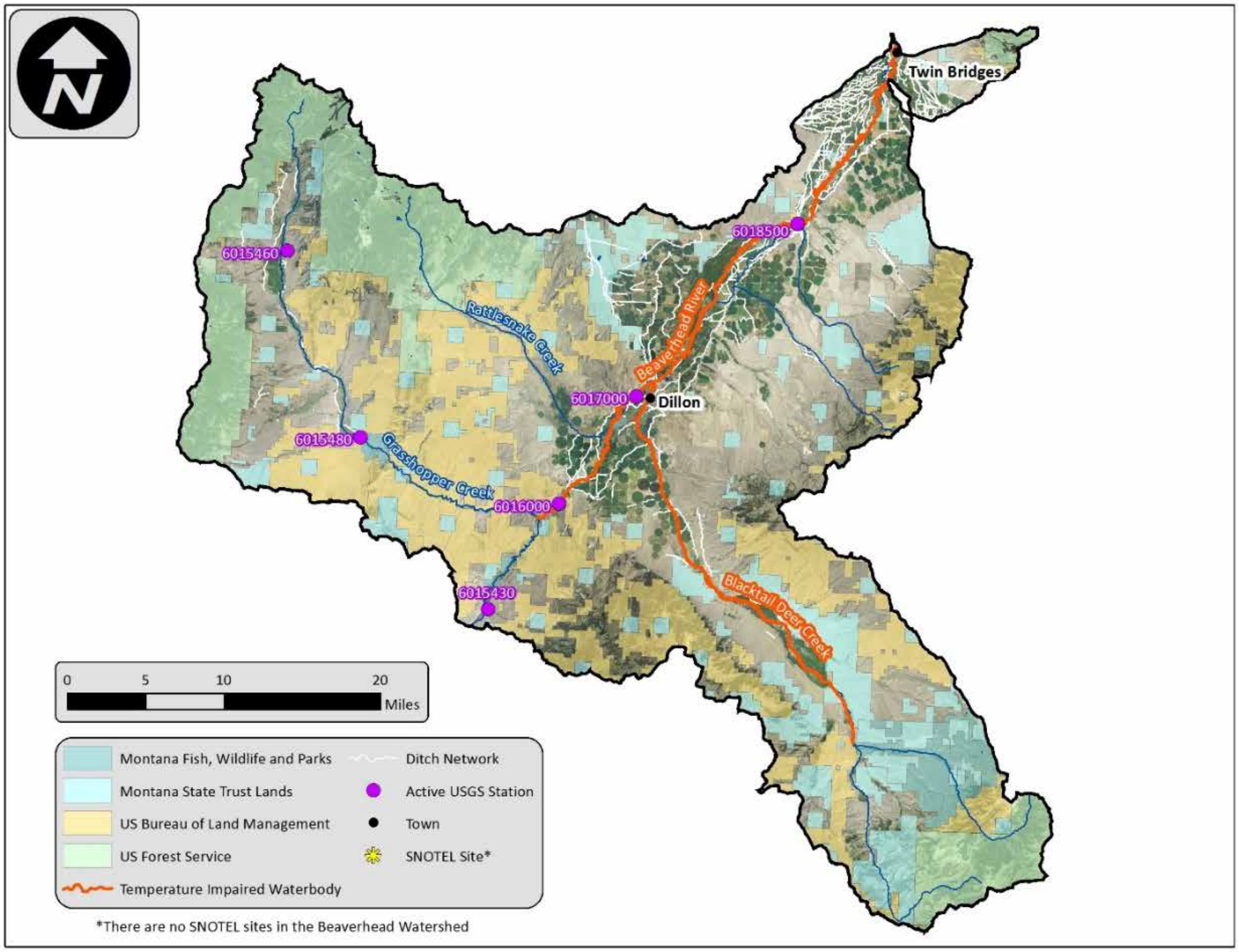

FIGURE 8 Beaverhead Watershed

BEAVERHEAD WATERSHED

GEOGRAPHY: The Beaverhead Watershed in southwestern Montana lies mostly within Beaverhead County with small portions in Madison County. It is predominantly a snowmelt-driven system situated on the eastern boundary of the Continental Divide at the headwaters of the Missouri River. Elevations range from around 4,600 feet along the Beaverhead River to over 11,000 feet in the Pioneer Mountains. Clark Canyon Dam (CCD) impounds flows from the Red Rock River and Horse Prairie Creek and marks the beginning of the Beaverhead River, which meanders 69 miles northeast past the City of Dillon until it's confluence with the Ruby and then the Big Hole River near Twin Bridges, at which point it becomes the Jefferson River. Notable tributaries of the Beaverhead River include Grasshopper Creek and Rattlesnake Creek from the west, and Blacktail Deer Creek and Stone Creek from the east.

LAND AND WATER USE: Beaverhead County's 3.55 million acres are comprised of 59% federal land (USFS, BLM, BOR, USFWS), 10% state land (DNRC, FWP), and 31% private land. Of the county's 9,341 residents (US Census, 2013), about 20% rely upon agriculture and forestry for their livelihood. According to the Montana Department of Agriculture, Beaverhead County was the top beef producing county in Montana and the third highest sheep producing county in 2013. Approximately 80% of the 97,200 acres harvested in Beaverhead County in 2012 were feed crops such as alfalfa and hay, while the other 20% consisted primarily of spring wheat, barley, and seed potatoes. Most, of the acres are irrigated. There are more than two million acres of range providing excellent summer and fall forage for cattle and sheep. Therefore, many producers cycle their livestock between their private pasture lands in the winter and spring, and public land grazing allotments during the summer and fall. The agricultural economy in Beaverhead County suffers disruptions when drought conditions limit available water supplies for irrigation and inhibit forage production on the landscape. The Beaverhead River is a blue-ribbon trout fishery that is renowned for the abundance and size of brown trout in its waters. The Beaverhead Watershed and its headwaters also support other species such as rainbow trout, west slope cutthroat trout, and Arctic grayling. Therefore, angling recreation and tourism is another important component of the local economy. The most common impacts to this industry due to drought are low stream flows and high stream temperatures which can stress and kill fish, impair water quality, trigger angling restrictions, and discourage recreation and tourism. This not only affects local outfitting businesses, but also local hotels, restaurants, and other businesses.

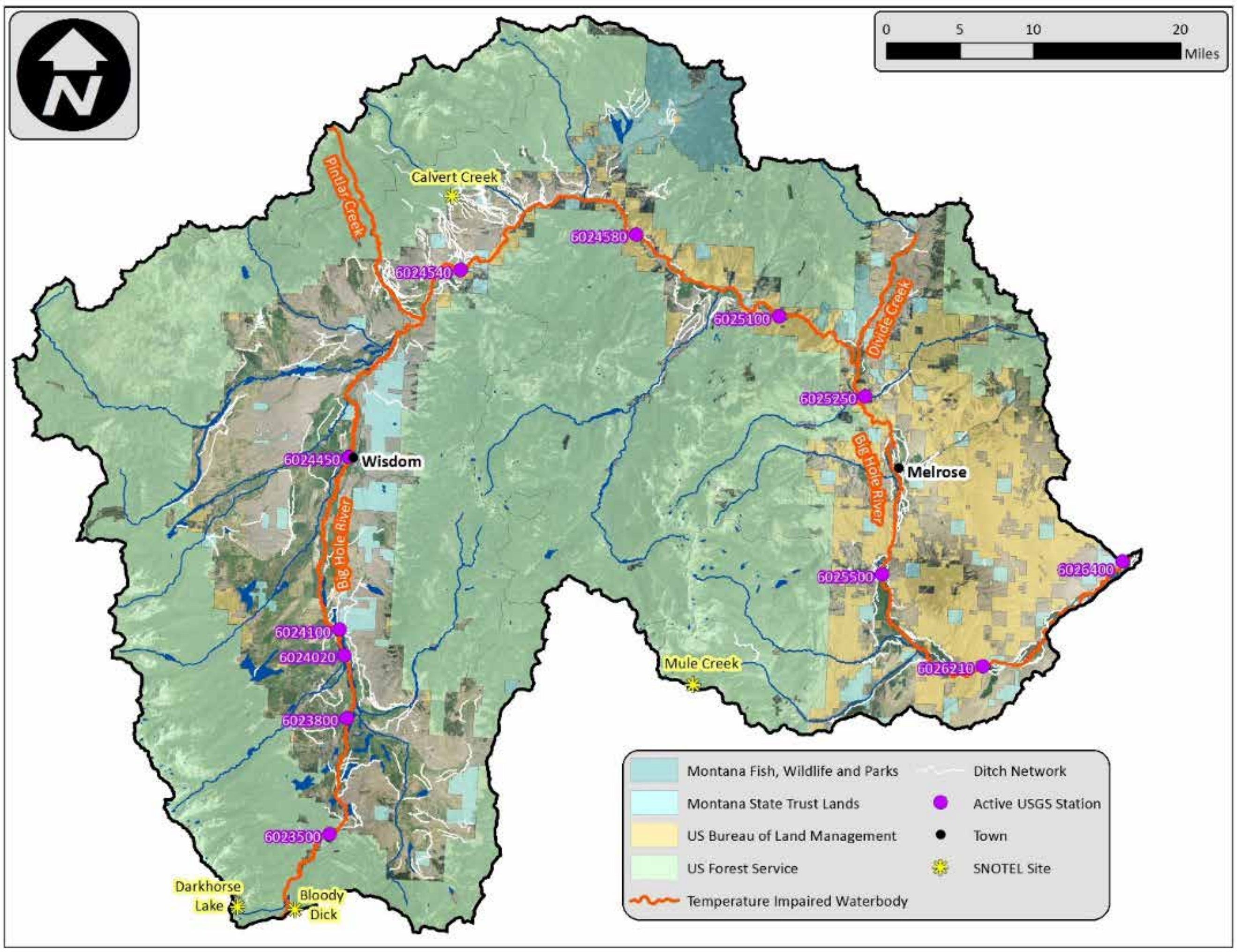

FIGURE 9 Big Hole Watershed

BIG HOLE WATERSHED

GEOGRAPHY: The Big Hole Watershed encompasses the Big Hole River and its surrounding landscape in Southwest Montana. The watershed includes parts of four counties: Beaverhead, Madison, Butte-Silver Bow, and Anaconda-Deer Lodge. The Big Hole Watershed is a stronghold of traditional cattle ranching, rural communities, and expansive public lands. Nearly 2,000 residents call the Big Hole valley home, spread among its nearly 2 million acres. In general, the valley bottom remains privately-owned. Highlands are publicly-owned by state and federal agencies, the majority U.S. Forest Service (USFS) Beaverhead-Deerlodge National Forest (BDNF). Elevations range from 5,000 to 6,500 feet at the valley bottom to more than 10,000 feet at the highest peaks. The nearby 158,000-acre Anaconda-Pintler Wilderness at the north end of the watershed was established in 1964 as part of the original Wilderness Act and includes some of the highest peaks in the drainage at well over 10,000 feet. The Big Hole River is a headwater tributary of the Upper Missouri River. It is nestled against the Continental Divide and is solely reliant on snowpack and precipitation for its water sources. The Big Hole River starts at Skinner Meadows Road near the town of Jackson, flows almost 155 miles through the towns of Wisdom, Wise River, Dewey, Divide, Melrose, and Glen, where it meets the Beaverhead River and flows into the Jefferson River near Twin Bridges to form the Missouri Headwaters.

LAND AND WATER USE: The Big Hole Watershed has a total area of approximately 2500 square miles, with roughly 69% being Federal lands (USFS, BLM, NPS), 4% State lands (DNRC, MFWP), and 27% private lands. The Big Hole River valley is a high elevation basin at the headwaters of the Upper Missouri River characterized by open lands, big sky and big mountains, free-flowing river, and traditional ranching culture. Unlike many other watersheds in the West, the area remains relatively undeveloped. The primary land uses in the Big Hole Watershed are cattle/sheep ranching and hay production. The Big Hole River is also a blue-ribbon trout fishery that is renowned for hosting the last fluvial population of Arctic grayling in the lower 48 states. The Big Hole Watershed supports other fish species such as rainbow trout, brown trout, brook trout, Westslope Cutthroat trout, mountain whitefish, burbot, longnose dace, longnose sucker, Rocky Mountain sculpin, and white sucker as well as grayling. The majestic scenery, thriving fishery, and abundance of public access make the fishing outfitting and guiding business (and associated tourism) a staple of the economy in the Big Hole Watershed. The outfitting and guiding industry experiences severe impacts from drought, including mandatory fishing restrictions to protect the fishery during times of drought (as characterized by low stream flows and high stream temperatures which can stress and kill fish).

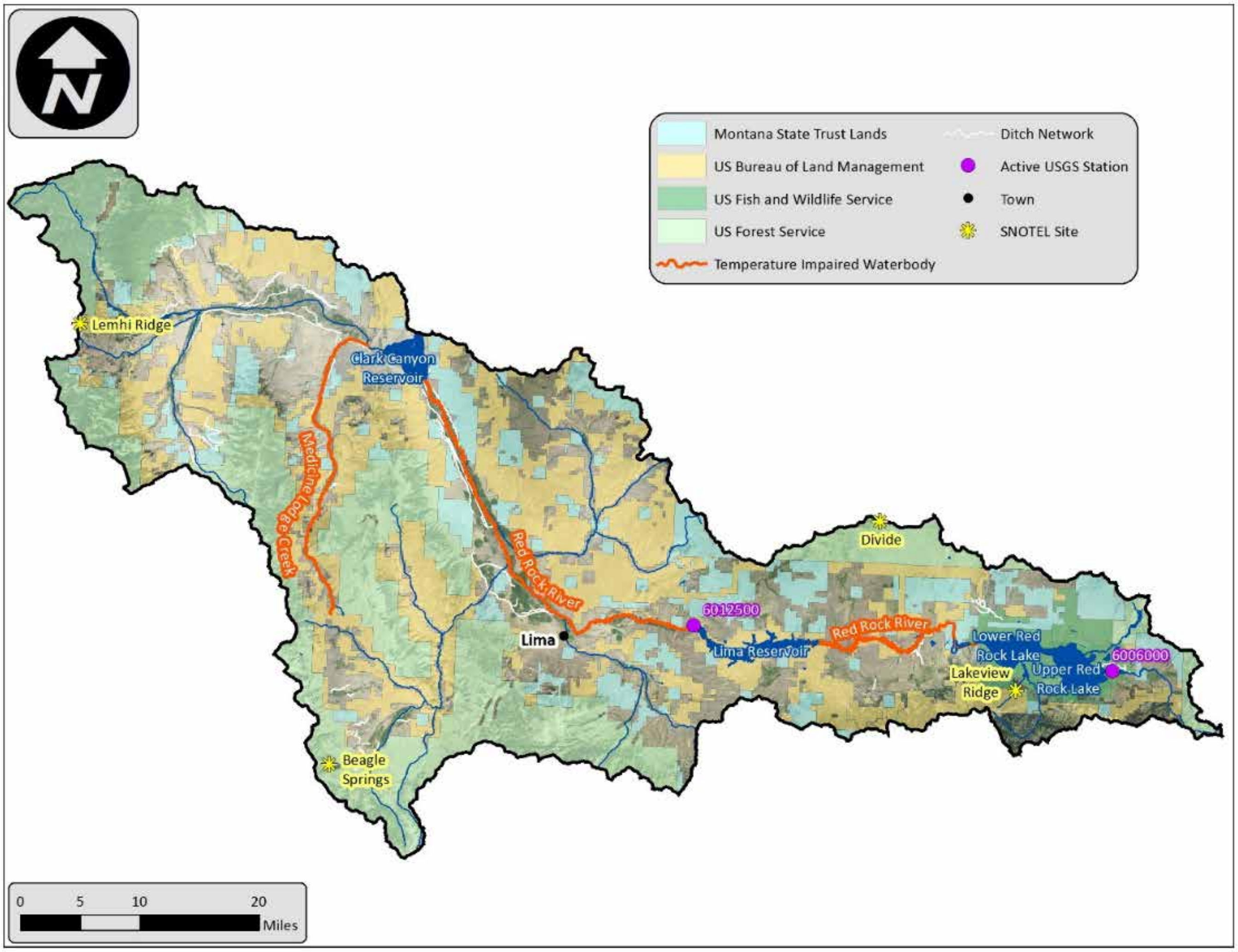

FIGURE 10 Centennial Valley (Red Rock River)

CENTENNIAL VALLEY (RED ROCK RIVER)

GEOGRAPHY: The Centennial Valley, a 385,000-acre high-altitude valley, runs east to west and is defined by the Gravelly, Snowcrest, and Madison Mountain Ranges to the north and the Centennial Mountain Range to the south. At 9,100 ft above sea level on Mount Jefferson, Brower's Spring is the true headwaters of the Missouri River. It flows into Hell Roaring Creek and down to Red Rock Creek to Lima Dam and out onto the Red Rock River. The Red Rock meets with the Beaverhead River at Clark Canyon Dam and flows on to the Jefferson River.

Situated just northwest of Yellowstone National Park, the Centennial Valley is a hotspot for natural biodiversity. It has an abundance of diverse and high-quality habitat types, including wetlands, a sagebrush-grassland mosaic that contains unique sandhills, mid-elevation coniferous forests, aspen stands, and alpine forest communities. It varies in elevation from 6,600ft. at the valley floor to over 10,000ft at Mt. Jefferson on the southern side of the valley. There are rolling sage brush hills and heavily wooded areas, as well as riparian areas flush with willows. Wetlands encompass 45,000 acres of the valley, 25,000 acres of which are protected through the Red Rock Lakes National Wildlife Refuge. The valley also includes over 500 miles of riparian areas. The wetland/riparian areas are identified as one of the highest quality examples of an intact aquatic system in the Upper Missouri basin and the largest wetland complex in the Greater Yellowstone. Drying of the watershed and an increase in temperature to this sensitive ecosystem is a major concern for many stakeholders involved. Approximately 100,000 acres of the total 385,000 acres in the valley are considered grasslands and 130,000 acres are considered sagebrush. There are sandhills located on the northeast side of the valley that host a diverse set of wildlife including, 18 species of mammals, 29 species of bird, two amphibian species, one reptile species, four species of tiger beetles, and 14 species of diurnal butterflies. There are three main forest ecosystems in the Centennial Valley: mid-elevation coniferous forests, aspen stands, and high-elevation forests. The mid-elevation forests surround the valley and precipitation can be double in these stands than what it is at the valley floor. These forests host a variety of wildlife, including the goshawk, great gray owl, and the grizzly bear. The aspen stands in the valley are considered some of the most pristine in southwest Montana. There are approximately 33,000 acres of aspen stands scattered throughout the valley. These are sites of concern for the future regarding climate change and protecting endangered species. Above 8,500 feet in the Centennial Mountains is a mosaic of forest and alpine meadow habitats. These exposed mountain ridgelines and peaks provide a unique habitat for the alpine plant and animal communities. These communities will be highly vulnerable to climate change and are areas of concern for the future.

LAND & WATER USE: Humans have frequented the Centennial Valley for thousands of years. The valley was well known to many groups of Native Americans. It was frequently visited by branches of the Shoshone tribe, as well as the Blackfoot, Crow, Flathead, Bannocks, and Nez Perce tribes. Observable evidence, such as tepee rings, arrow and spearheads, and pottery shards, have been collected throughout the valley over the years. Groups of Native Americans continued to frequent the valley after the turn of the century and after settlers had begun to homestead the area. The short summers and harsh winters eventually caused most of the homesteader families in the Centennial to either leave, selling their property to other ranching operations, or to adapt their land use in the valley to summer grazing and moving their livestock out of the valley to overwinter in nearby communities. Few of the recreational hunters and fishermen who traveled to the valley for sport braved the valley during the colder months of the year, a pattern that continues today. Despite the abundant streams, the valley is generally a dry place, and in dry years the lack of water posed a constant threat for the agricultural community. This constantly looming worry led to the construction of an earthen dam at the west end of the valley in the 1890's, the first incarnation of Lima Dam, providing water for irrigation to 20,000 acres in a typical year, as well as providing stock water for livestock, and ensuring summer flows for fish and wildlife. There are currently 14 active cattle ranches in the Centennial Valley that run approximately 12,000 head of cattle during the summer months.

There are two shallow lakes that dominate the valley floor: Upper Red Rock Lake (2,206 acres) and Lower Red Rock Lake (1,126 acres), both protected through the Red Rock Lakes National Wildlife Refuge. Both lakes are less than 6 feet in depth and host a wide variety of avian species. The Lima Reservoir, located at the western end of the valley, is approximately 84,000 acre/feet at 100% capacity. The water users prefer that the reservoir stays above 10,000 acre/feet, as water quality declines any lower. The average capacity is around 70,000 acre/feet.

Red Rock Lakes National Wildlife Refuge currently owns 51,386 acres and manages conservation easements on an additional 23,806 acres. There are 260 bird species that have been found in the valley - 70% of all the birds found in Montana. There are also populations of black bears, grizzly bears, martens, weasels, minks, badgers, river otters, beavers, wolverines, skunks, fox, coyotes, wolves, cougars, lynx, raccoons, and bobcats. The ungulate population consists of elk, white-tailed deer, mule deer, moose, and pronghorn. The Centennial Valley is one of the few places that the Arctic grayling continues to persist in the lower 48 and the Westslope cutthroat trout has been declining throughout its range, causing concern. The predicted changes in snowmelt runoff, as well as increased annual temperatures could potentially make these waters uninhabitable for these species.

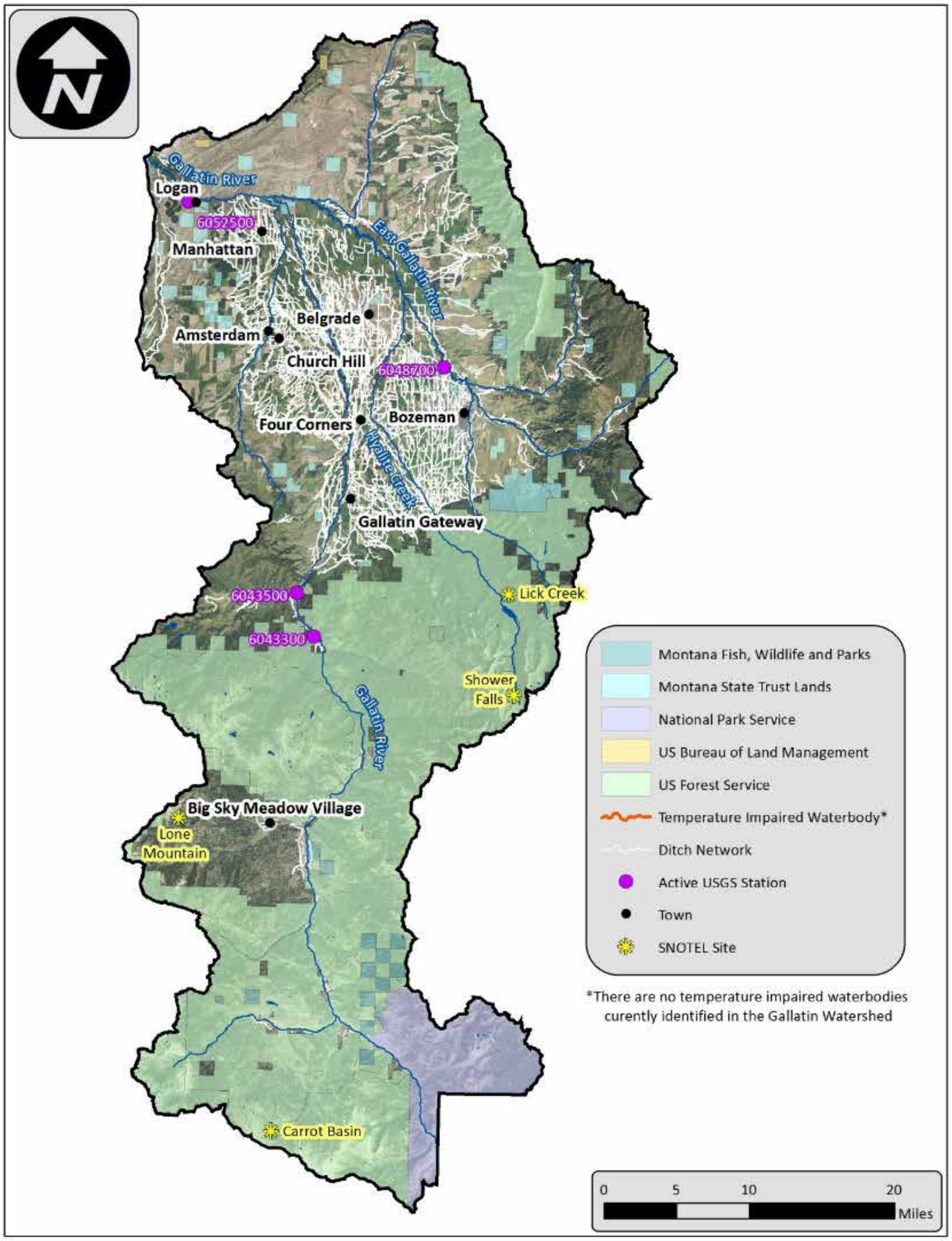

FIGURE 11 Gallatin River Watershed

GALLATIN RIVER WATERSHED

GEOGRAPHY: The Gallatin River originates in Yellowstone National Park, and is further supplemented by streams from the Madison, Gallatin, and Bridger mountain ranges. The main stem is unregulated, although Middle Creek Dam on Hyalite Creek captures and stores about 10,200 acre-feet of water. Gallatin streamflow has been recorded at the USGS Gallatin Gateway gage from 1930-present, with higher flows measured during spring runoff in the 1960's, 1970's and 1990's and lower flows during spring runoff in the 1930's, 1980's and 2000's. When comparing the period between 1930-1995 and 1995-2015, there is some evidence of higher runoff in May and June, with lower late-season flows in the past 20 years. High flow measurements conducted in the West Fork Gallatin River watershed estimated a peak flow of approximately 1,000 cfs in 2008 in the West Fork Gallatin River when the Gallatin mainstem was flowing approximately 6,000 cfs, indicating the West Fork Gallatin River watershed contributes approximate 15% of the Gallatin River mainstem flows during high water.

Groundwater in the Big Sky area is recharged annually by winter snowpack and large rain events and currently provides a sufficient water supply, though supplies may not be extensive enough to meet projected future needs without innovative water resources management. The primary water supply source in the Big Sky area is groundwater obtained from wells operated by Big Sky Community Water and Sewer District (BSCWSD), Yellowstone Club, and Spanish Peaks in the West Fork Gallatin River watershed and Moonlight Basin in the Jack Creek watershed. There are several geologic formations from which groundwater is drawn in the Big Sky area, including sand and gravel aquifers, sandstone and shale aquifers, Madison limestone aquifers, and fractured bedrock aquifers. Sand and gravel aquifers and fractured bedrock aquifers, in which the BSCWSD water supply wells are located, provide high quality water, while sandstone and shale aquifers, in which many private wells in the Big Sky area are located, often provide lower quality water.

The Gallatin River system has native salmonids, with Westslope cutthroat trout indicating the cleanest, coldest, highest value waters. Wildlife values include grizzly bears, elk, and big horn sheep. Recreational values contribute substantial economic benefits. Fishing (100,000 angler days/year, worth 40-52 million dollars a year), rafting (20,000 people commercially guided per year; 4.6 million dollars based on the 2006 EIS by DEQ for the Outstanding Resource Water designation), and hiking all contribute. Scenic values are also tremendously high on the Gallatin River.

LAND AND WATER USE: The Upper Gallatin watershed is home to the rapidly growing mountain resort community of Big Sky which sits at the base of Lone Peak in the Gallatin Range, just north of Yellowstone National Park and nestled between the Spanish Peaks and Lee Metcalf Wilderness areas. The original Big Sky alpine ski resort was established in 1973, but several neighboring resorts (Yellowstone Club, Moonlight Basin, and Spanish Peaks) have increased the popularity of the area with current population estimates at about 2,600 full-time residents. Population projections estimate a future population of 4,500-14,000 residents in the Big Sky area, while a build-out study conducted in 2011 estimates approximately 7,400 residential units and places maximum future population as high as 16,000. A 2014 Community Profile stated that 15,000+ visitors per day are present during the peak of the ski season, while additional data also indicate that summer-time visitation has been increasing. As growth continues, the level of occupancy by full-time and part-time residents will greatly affect water withdrawals and wastewater generation in the Big Sky area.

The Big Sky area is fragmented politically since it is unincorporated and situated in two counties. There are several large landowners and land managers in the Big Sky area, including Big Sky Resort, Yellowstone Club, Lone Mountain Land Company, Town Center, U.S. Forest Service, and Montana Fish, Wildlife and Parks (FWP), along with numerous smaller developments and individual landowners. The water infrastructure of the Big Sky area is managed by multiple entities, with groundwater aquifers of varying productivity and quality providing water for personal homes, businesses and the ski resorts. In general, the Big Sky area water supply is high in calcium, which results in "lime scale" that is often treated by individual homeowners using water softeners that add salt to the water.

Established monitoring of annual water production in the Big Sky area includes groundwater monitoring conducted by Montana Bureau of Mines and Geology, BSCWSD, and Gallatin Local Water Quality District, along with streamflow measurements conducted by the Task Force at four monitoring sites in the West Fork Gallatin River watershed. In addition, the USGS operates streamflow gaging stations on the Gallatin river. Annual precipitation data is collected at the NRCS Lone Mountain Snow Telemetry (SNOTEL) site, the Western Regional Climate Center (WRCC) Big Sky 3 S (COOP) site, and by area ski resorts. The Lone Mountain SNOTEL site has recorded variable precipitation over the 1992-2015 timeframe (annual precipitation range: 26.2" to 42.9"; average of 33.7"), with increasing temperatures observed over this timeframe (average air temperature range: 31°F to 38°F; average of 38°F in 2015). Water use is highest in the summer with projected increasing demand. Development can increase evapotranspiration and decrease infiltration as the amount of impervious surfaces increases.

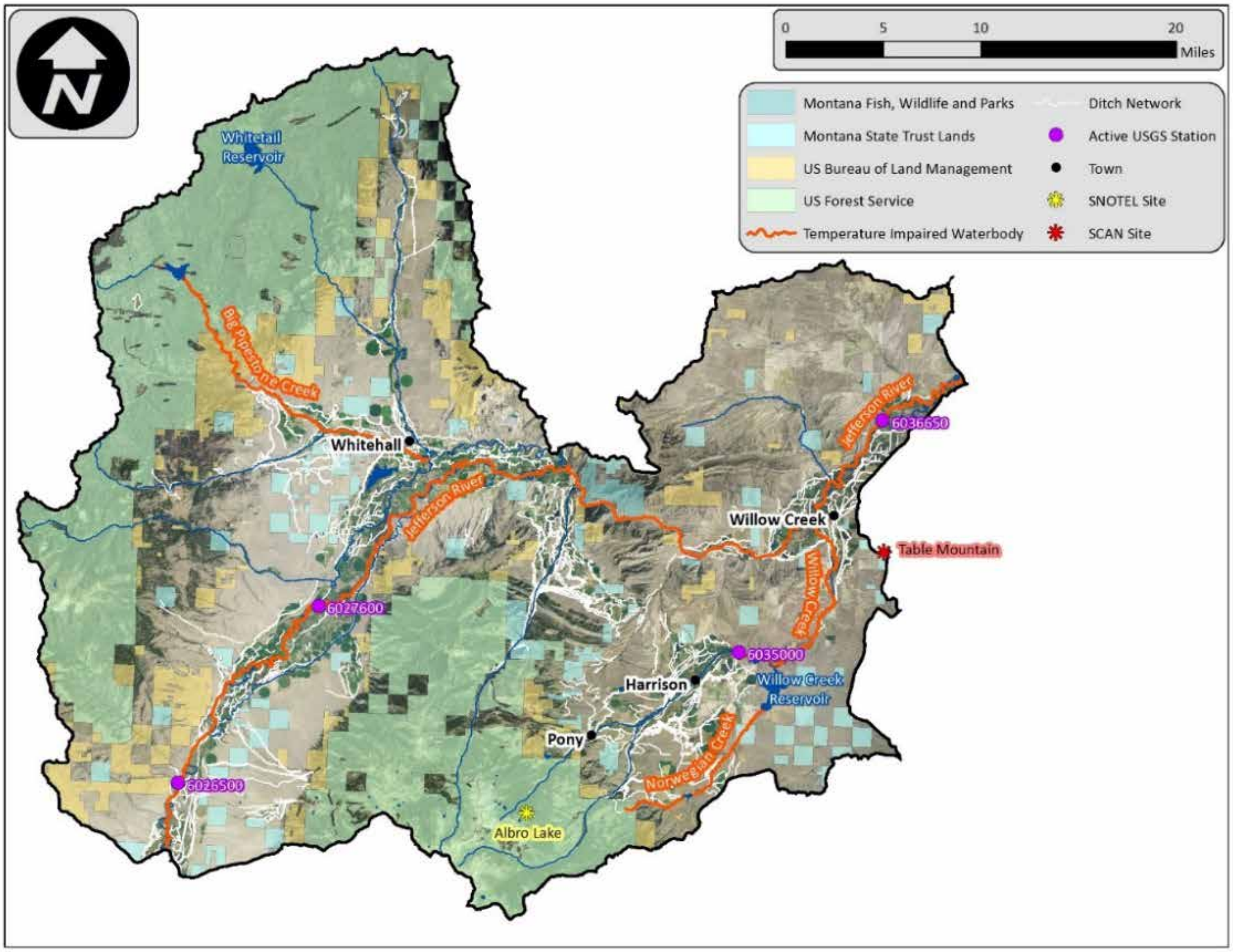

FIGURE 12 Jefferson River Watershed

JEFFERSON RIVER WATERSHED

GEOGRAPHY: The Jefferson River is formed by the confluences of the Ruby, Beaverhead, and Big Hole Rivers near the town of Twin Bridges, Montana and flows for nearly 84 miles before combining with the Madison and Gallatin Rivers at the headwaters of the Missouri River. The basin relief ranges from about 4000 feet in the valley to over 10,000 at the plateau of the Tobacco Root Mountains. The Boulder River and Willow Creek are major tributaries to the Jefferson River. Other tributaries that originate in the Tobacco Root and Highwood Mountains also add flow to the Jefferson. The upper Jefferson River watershed area encompasses approximately 734 square miles of land in Jefferson and Madison counties beginning at the Jefferson River's point of origin near Twin Bridges and extending to its confluence with the Boulder River near Whitehall

LAND AND WATER USE: The Jefferson Watershed supports fishing, hunting, birding, off-road vehicle use, canoeing, floating and camping among other recreational opportunities. The Jefferson River itself, supports a healthy primarily brown trout fishery with relatively low fishing pressure compared to nearby southwest Montana rivers. Of the total land area over 100,000 acres, or 12 percent is irrigated with most of the irrigation occurring in Madison and Jefferson Counties. The major land resource areas in the Jefferson Watershed include evergreen forest and grassland. Crops including potatoes, sugar beets, peas, hay grain and pasture for livestock feed, dominate the landscape. About 52,000 acres are irrigated from the Jefferson River and smaller tributaries, with another 12,000 acres irrigated from the Boulder River. Flows are regulated on the Willow Creek tributary by Willow Creek Reservoir with a capacity of 17,700 acre-feet, Delmoe Lake regulates 6,000 acre-feet distributed to Big Pipestone Creek and Whitetail Reservoir maintains 4,900 acre-feet above Whitetail Creek. There are six major irrigation projects accounting for 25 percent of the total irrigated acreages with the remainder serving smaller irrigation projects and private ditches. Communicating with these larger ditch companies, the Jefferson River Watershed Drought Plan has been an effective mechanism in maintaining target flows on the main stem of the river and to set a standard for temperature dependent fishing restrictions.

The Jefferson River valley is mostly agricultural, and contains the small communities of Silver Star, Waterloo, Whitehall and Cardwell. Hardrock mining has persisted in the area for many years, and the open pit, Golden Sunlight Mine operates just outside of Whitehall. The area is beginning to experience some overflow from the Bozeman growth boom but remains mostly rural residential.

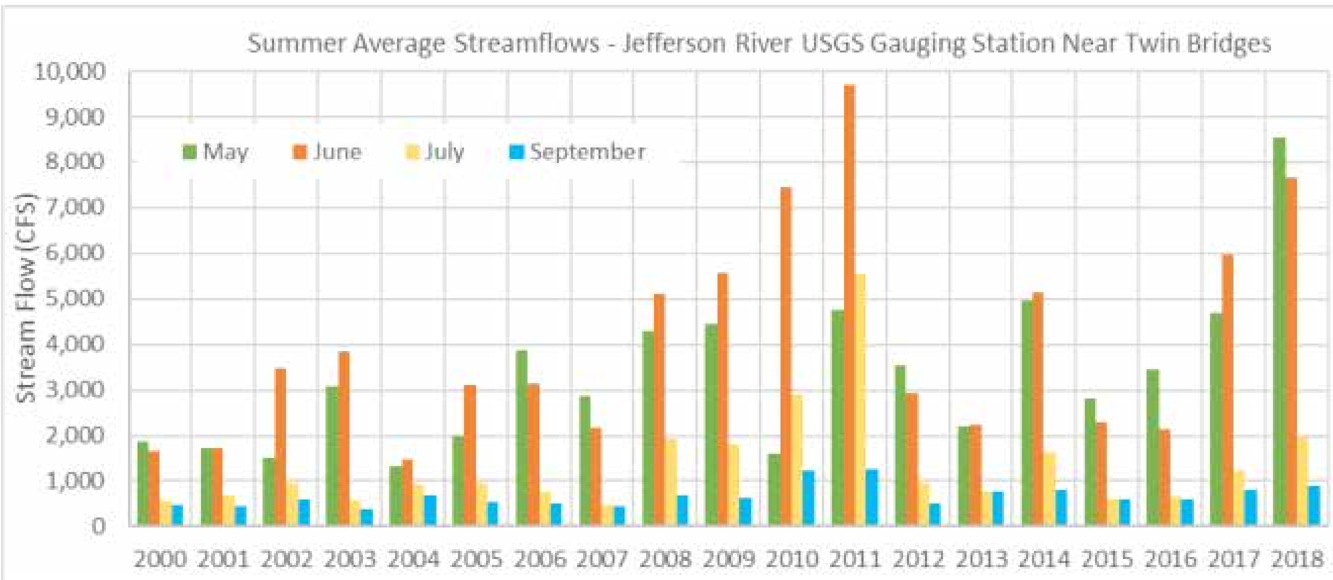

TABLE 7 Average Summer Streamflows - Jefferson River, *USGS*

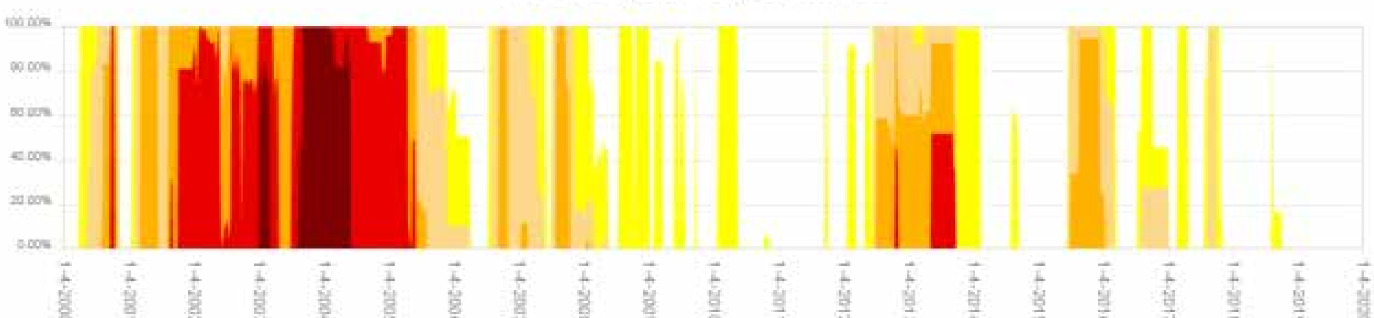

Figure 17: U.S. Drought Monitor Percent Area in Drought Conditions for Jefferson River Watershed 2000-2019

TABLE 8 Jefferson River Drought Intensities 2000-2017

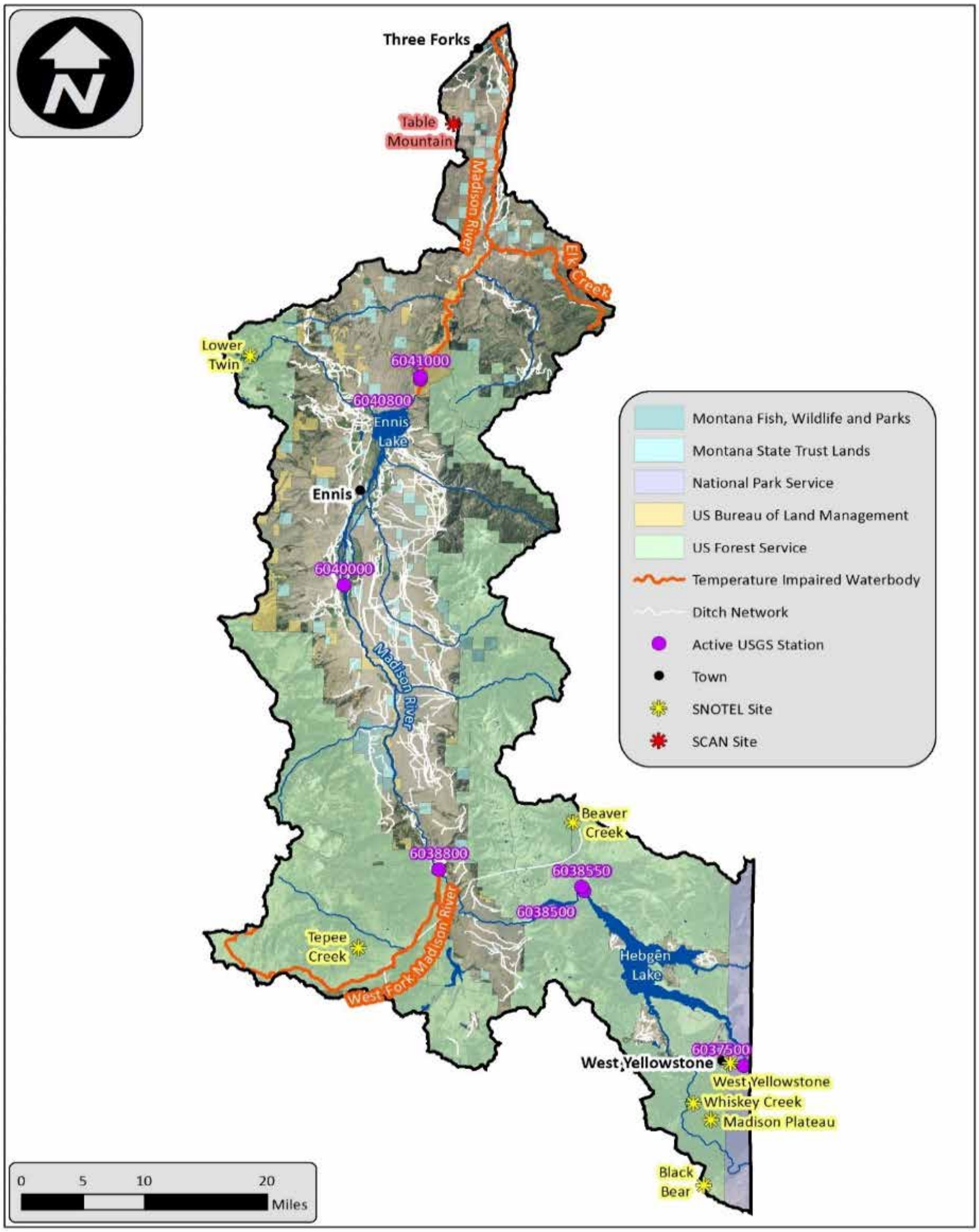

FIGURE 13 Madison River Watershed

MADISON RIVER WATERSHED

GEOGRAPHY: The headwaters of the Madison River lie within the boundaries of Yellowstone National Park, with important flow contributions coming from tributary streams in the Madison, Gravelly and Tobacco Root mountain ranges. Mountain snowpack feeds thousands of miles of streams that support productive agricultural lands, distinctive fish and wildlife populations, and vibrant communities that continue to grow throughout the Madison Valley. Nearly 3,000 miles of tributary streams feed into the Madison River before forming the Missouri River.

The Madison Watershed encompasses 1,635,790 acres within Montana and Wyoming. Most of the watershed is within the boundaries of the Madison Conservation District. However, there are some fragmented sections that also fall within the jurisdiction of the Gallatin Conservation District, Beaverhead Conservation District, and Ruby Valley Conservation District. There are several public agencies that own or manage land in the watershed, including the Beaverhead-Deerlodge National Forest, Custer-Gallatin National Forest, Bureau of Land Management, Montana Department of Natural Resources and Conservation, Fish Wildlife and Parks, U.S. Fish and Wildlife Service, National Park Service, etc.

LAND AND WATER USE: Land uses throughout the Madison Valley have evolved over the last century, but generally consist of residential development, agricultural production, recreation, mining, and other activities common on public lands. Of the 1.2 million acres of land in the Madison Valley within Montana's borders, nearly 60% is in public ownership. Meanwhile, of the remaining acreage in private hands, nearly 88% are in agricultural production, leaving the rest to residential development. The number of houses in Madison County doubled during the 30-year period from 1982 to 2012. Over the last two decades, roughly 90% of that development has been in rural areas. However, the Madison Valley also has a high proportion of private land in conservation easements, totaling over 224,000 acres (46.5% of private lands). This land is restricted from future development, and provides future habitat, open spaces, and agricultural production opportunities in perpetuity. In addition to the footprint consumed by development, there is also growth in the number of wells that are servicing these new homes. General household water consumption tends to be relatively low, however the greatest use of residential water supply goes toward lawn and garden irrigation.

Water is one of the most valuable and essential resources in the Madison Valley. It is the lifeblood of the high-elevation forests, productive agricultural lands, abundant fish and wildlife, and expanding residential population. This water, however, is a finite resource with growing demands. Each year, mountain snowpack feeds thousands of miles of stream that support productive agricultural lands, distinctive fish and wildlife populations, and vibrant and growing communities throughout the Madison Valley.

Farming and ranching are the very core of the heritage and culture of the Madison Valley. This agricultural industry provides food for the community, and open spaces for scenic viewsheds and wildlife habitat. In a semi-arid landscape like the Madison Valley, water is critical to the success of agricultural production. Since the late 19th century, farmers and ranchers have put water from our streams and rivers to beneficial use by spreading this resource across the landscape to provide water for their crops and livestock.

Irrigation techniques have evolved in recent decades, and traditional flood irrigation has given way to more efficient sprinkler setups throughout the valley. Changes from flood irrigation, however, can have implications to surface water and groundwater storage due to the connected nature of surface and groundwater. Controlled flooding of crop and pastureland allows excess water to recharge the aquifer, whereas sprinklers and pivots use water more efficiently and allow potential opportunities for leaving excess water in streams for other uses.

The number of houses in Madison County doubled during the 30-year period from 1982 to 2012. Over the last two decades, roughly 90% of that development has been in rural areas. In addition to the footprint consumed by development, there is also a growth in the number of wells that are servicing these new homes. General household water consumption tends to be relatively low. However, the greatest use of residential water supply goes toward lawn irrigation.

Each year, hundreds of thousands of visitors come through the Madison Valley to enjoy its scenic viewing and recreation opportunities. Surveys show that 96% of visitors come to Ennis for some form of outdoor recreation opportunities, while 37% come for fly fishing alone. The upper Madison River is among the most famous fly-fishing destinations in the country, and one of the most popular in Montana. The Montana Department of Fish Wildlife and Parks estimates it sustained 180,000 angler days in 2017.

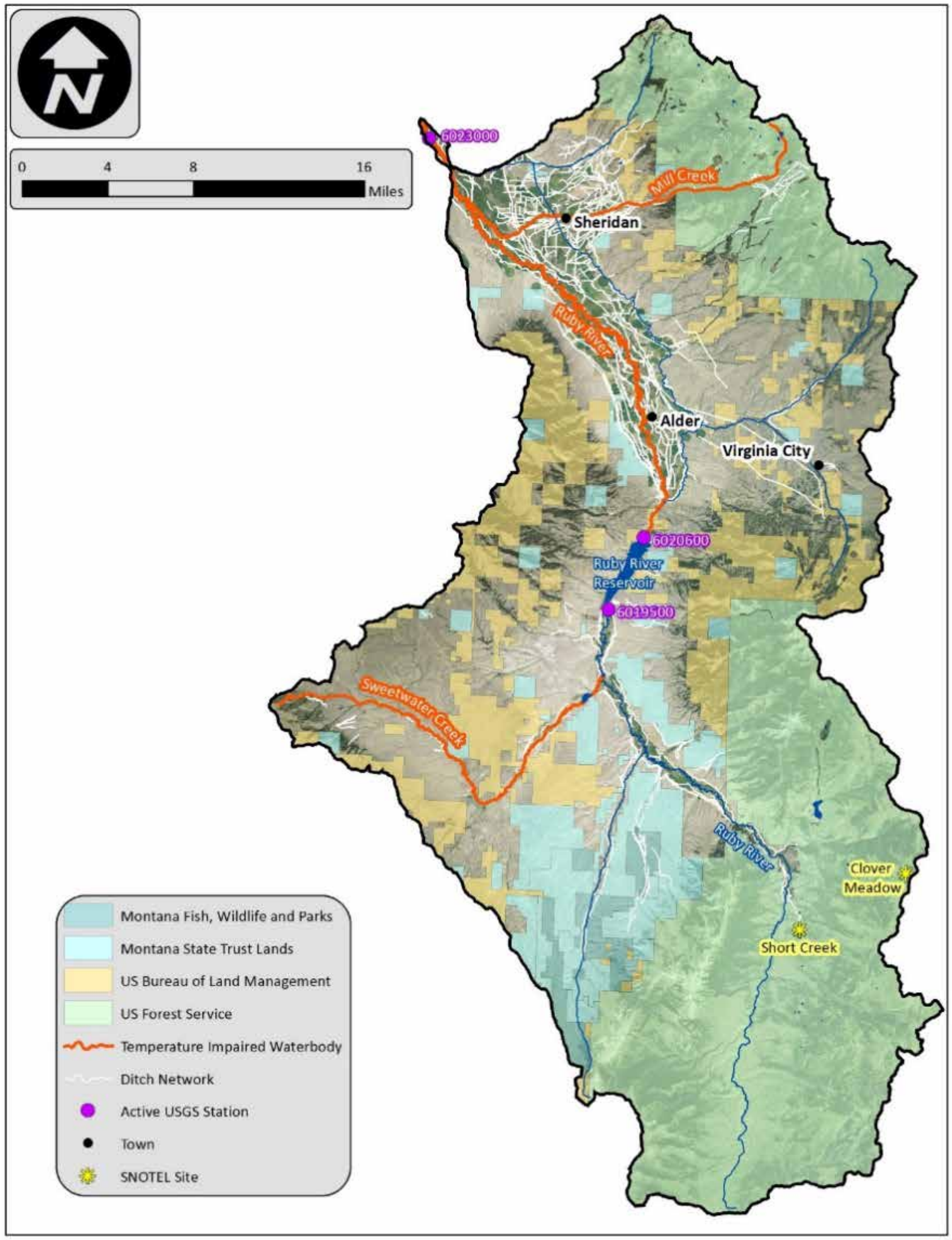

FIGURE 14 Ruby River Watershed

RUBY RIVER WATERSHED

GEOGRAPHY: The Ruby Watershed is a 623,000-acre rural valley which is hydrologically dissected into two areas of interest: The Upper and Lower Ruby Rivers. The Ruby River originates in the Snowcrest, Gravelly, and Greenhorn mountain ranges, with flow contributed to the lower Ruby River from tributaries in the Ruby and Tobacco Root mountains. The Ruby Reservoir, built in the late 1930s with the specific purpose of storing irrigation water, splits the watershed in two. Most of the water supply in the watershed is generated in the Upper Ruby, while most of the water use occurs in the Lower Ruby. Approximately 36,000 acres are irrigated in the Ruby. The Ruby Reservoir, built in 1938, has a maximum capacity of 37,642-acre feet. Irrigation water supply in the Ruby River watershed is a combination of decreed rights from the river and its tributaries and delivered or "contract" water which is released from the Ruby Reservoir. The tributaries below the reservoir are used to supplement irrigation demand and often experience seasonal dewatering.

LAND AND WATER USE: Drought is a frequently occurring phenomenon in the Ruby River watershed. Locally, agriculture is highly adapted to the frequency and occurrence of drought. Principally, drought is addressed through the regulation of water supply from the Ruby Reservoir. During times of extreme stress on the system, water users participate in a voluntary drought management plan, titled "The Plan to Prevent the Dewatering of the Ruby." This is overseen by individuals who deliver irrigation water throughout the Lower Ruby. It relies on shared sacrifice of irrigation water during times of low water supply in order to maintain a minimum flow value of 20 cfs at all points on the Ruby River. This plan has been highly successful in preventing dewatering on the main stem of the Ruby River over the past two decades. Unfortunately, tributaries to the Ruby River do not have any such voluntary agreements. Many of the tributaries to the Lower Ruby are frequently dewatered. Several of these are dewatered nearly every year for several months at a time.

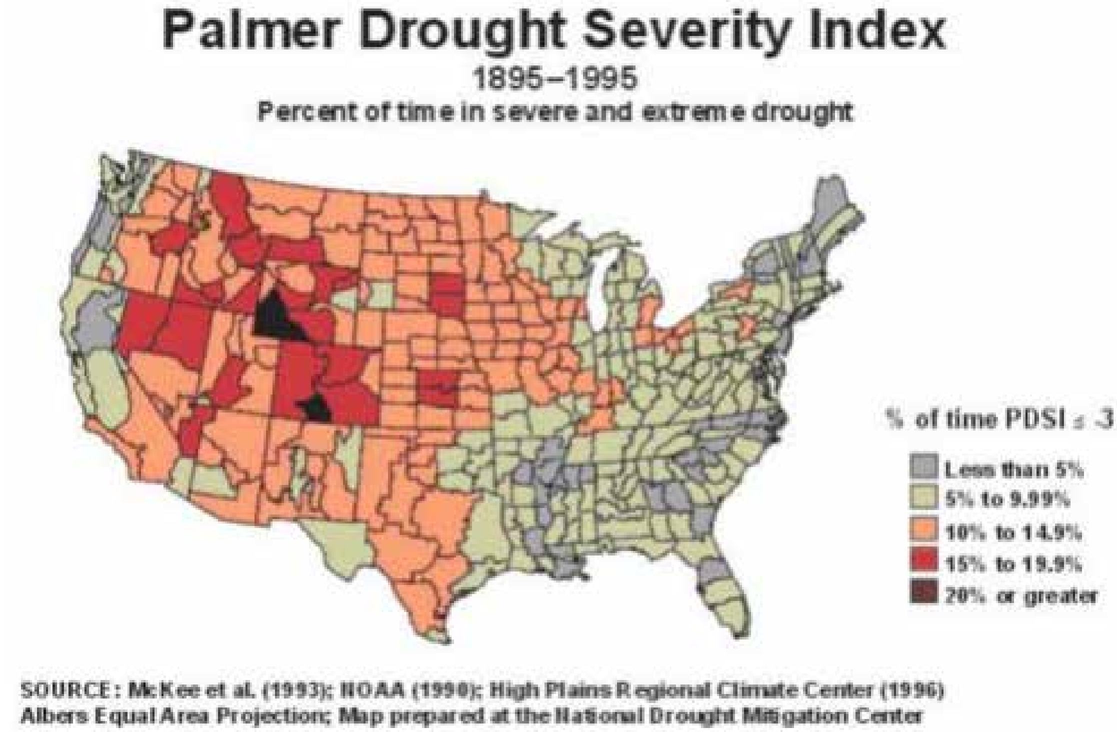

FIGURE 15 Drought Severity Index for the United States. Excerpted from the City of Bozeman Drought Plan

DROUGHT, CLIMATE AND FUTURE PROJECTIONS

In the Upper Missouri Impacts Assessment, historical water supply and demand were evaluated over the 50-year period from 1950 to 1999 (termed the historical scenario). Daily average temperatures in the study area increased by about 1.4 degrees Fahrenheit ( ) over the historical scenario; however, average annual precipitation did not exhibit a significant trend. Average snowpack on April 1, which is an indicator of seasonal snowmelt runoff, decreased during this period, corresponding with observed warming. Thus, the volume of annual runoff has not changed, but the timing of snowmelt and seasonal runoff peak has shifted toward earlier in the year.

Most of the consumptive water demands in the Upper Missouri River basin have historically been agricultural water use, comprising approximately 85 percent of the total consumptive use, or 1.7 million acre-feet per year. Reservoir evaporation comprises about 12 percent of the total consumptive use, while M&I use comprises just one percent of the total consumptive use. Most of the agricultural lands are within the river valleys, while precipitation falls primarily in the mountainous headwaters of the study area, resulting in reliance on the region's snowpack and storage reservoirs for water supply.

Meeting the needs of various water users in the study area has historically been challenging due to climate variability and long-term climate changes. The Dust Bowl Drought, which lasted from 1929 to 1943 (15 years) was the drought of record for the Missouri River basin draining to Fort Benton. The late century drought from 1985 to 1992 was almost as severe. During these droughts, on several of the tributaries irrigation demands exceeded the late-summer water supply, which led to stream dewatering. In 1988, both the Big Hole and Jefferson Rivers irrigation demands exceeded stream flow, which were not protected with any minimum instream flow requirements, and the rivers were nearly dry. The historical scenario period used was limited by naturalized streamflow data availability and consequently does not include either the Dust Bowl Drought (before the period in the 1930s) or the Millennium Drought (after the period in the 2000s). In some instances, to provide context to simulated historical conditions, the historical scenario flows are compared to observed conditions during these two droughts of record.

Water managers and farmers consider uncertain future conditions. Use of paleohydrology data, such as in the form of tree rings analyses, can provide additional historical context to existing conditions and may factor into operational or planning decisions. The Impacts Assessment analyzed tree rings and other data to examine conditions from 1100 - 1950 Common Era (CE) as well as analyzing the historical record. The paleohydrology analysis included extreme events: the Most Intense Drought (MID), Most Intense Pluvial (MIP), Longest Drought (LD), Longest Pluvial (LP). The historical record included severe droughts: the Dust Bowl Drought, the Mid-Century Drought of the 1950s, and the Millennium Drought. This analysis showed that the range in annual streamflow over the last 900 years is greater than the range over the historical scenario period. This is to be expected, in part because of the larger number of years contributing to the range.

Reviewing the Palmer Drought Severity Index from 1895-1995, we can see that the region is very prone to drought and has been in severe drought for 15-19.9% of the time. (See Figure 15.)

CLIMATE

The Montana Climate assessment was released in 2017 with a full chapter on Water Resources. Since the Upper Missouri Basin is a snowpack dominated system, many of the key messages predicted by the Climate Assessment resonate with water users in the basin and provide a strong basis for developing vulnerability assessments. The Assessment predicts that overall snowpack has declined, especially since the 1980s; that warming temperatures will likely reduce snowpack at lower and mid elevations; and that spring snowmelt is predicted to occur earlier in the season which will impact late season water availability. Combined with frequent droughts, the Climate predictions necessitate the need for greater understanding and long-term planning to reduce the potential impacts of exacerbated conditions and decreased water availability over longer, hotter summers in the Basin. Specifically, the Climate Assessment summarizes the following key messages:

- Montana's snowpack has declined over the observational record (i.e., since the 1930s) in mountains west and east of the Continental Divide; this decline has been most pronounced since the 1980s. [high agreement, medium evidence]11
- Warming temperatures over the next century, especially during spring, are likely to reduce snowpack at mid and low elevations. [high agreement, robust evidence]
- Historical observations show a shift toward earlier snowmelt and an earlier peak in spring runoff in the Mountain West (including Montana). Projections suggest these patterns are very likely to continue into the future as temperatures increase. [high agreement, robust evidence]
- Earlier onset of snowmelt and spring runoff will reduce late-summer water availability in snowmelt-dominated watersheds. [high agreement, robust evidence]
- Long-term (decadal and multi-decadal) variation in total annual streamflow is largely influenced by patterns of climate variability; the influence of climate warming on these patterns is uncertain. [high agreement, medium evidence]
- Total annual streamflows are projected to increase slightly for most Montana rivers, but the magnitude of change across the state and agreement among models vary. [medium agreement, medium evidence]
- Local responses of groundwater resources to climate change will depend on whether aquifers are directly sensitive to climate variability, are buffered from climate by water-use practices such as irrigation, or are used to meet water demands that exceed or replace surface water supplies. [high agreement, robust evidence]
- Groundwater demand will likely increase as elevated temperatures and changing seasonal availability of traditional surface-water sources (e.g., dry stock water ponds or inability of canal systems to deliver water in a timely manner) force water users to seek alternatives. [high agreement, medium evidence]
- Multi-year and decadal-scale droughts have been, and will continue to be, a natural feature of Montana's climate [high agreement, robust evidence]; rising temperatures will likely exacerbate drought when and where it occurs. [high agreement, medium evidence]
- Changes in snowpack and runoff timing will likely increase the frequency and duration of drought during late summer and early fall. [high agreement, medium evidence]
- A warming climate will strongly influence Montana's snowpack, streamflow dynamics, and groundwater resources, with far-reaching consequences for social and ecological systems. [high agreement, medium evidence]

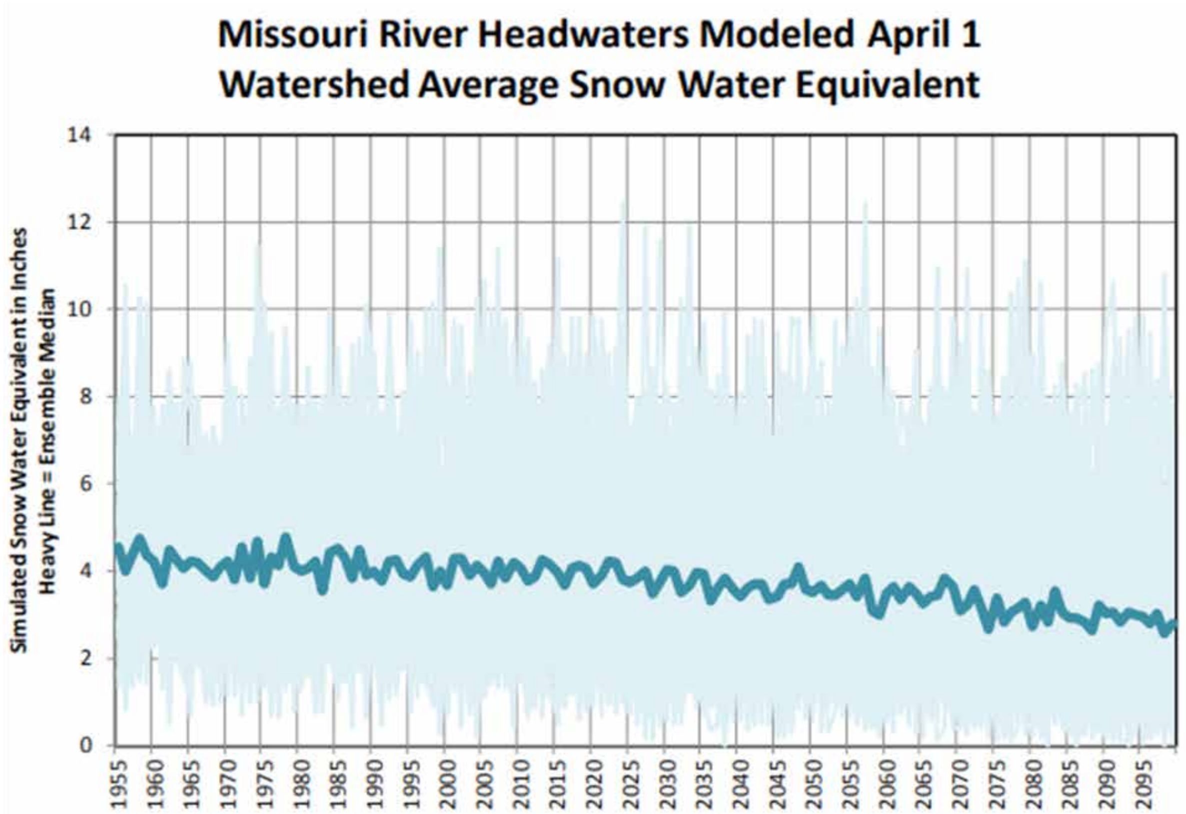

FIGURE 16 Upper Missouri Basin Plan: Modeled April 1 snow water equivalents for the Missouri River headwaters area based on VIC model results and downscaled projections from 112 GCM models.

In addition to the changes predicted in the Montana Climate Assessment, models developed through the Basin Study and based on the Impacts Assessment further support that changes in either water supply or demand will have a significant impact on communities, irrigators, hydropower plant owners, recreation interests, wildlife, and federally-listed species and their habitat.

Water shortages are common and increasing in the study area overall (as summarized in the Impacts Assessment), and it is likely that the current imbalances between supply and demand will be intensified in the future due to the following factors:

1) ***A warming climate and increased consumptive-use demands.*** Reservoir storage decreases correspond with projected increases in agricultural demand and reservoir evaporation. Most scenarios indicate an increase in reservoir evaporation, coupled with decreases in precipitation for most scenarios. Reservoir evaporation may be offset by precipitation increases in other months.
2) ***Changes in snowpack in headwater mountains with resulting changes in the amount and timing of snowpack runoff.*** The timing of inflow is projected to be earlier as we look further into the future for most of the region's reservoirs. Shifts in the volume and timing of snowpack storage will impact the region's reservoir operations, particularly during spring when operations must balance competing objectives of flood control and water storage for irrigation deliveries later in the season. End of water year storage is projected to decrease in the future for most reservoirs modeled.
3) ***Population growth and associated increased water demands.*** Communities in the headwaters already face challenges in providing water for a growing population, such as the Gallatin Valley, because most of the flow in the basin has been appropriated for irrigation, hydropower, and municipal uses along with instream flows needed to support fisheries and recreation.
4) ***Other water demands.*** Water supplies for fish, wildlife, and recreation, and to conserve threatened and endangered species are also needed.
5) ***Potential evapotranspiration is projected to increase*** during the 2010-2059 period when compared to the 1950- 1999 historic period under all but one of the 112 scenarios modeled. Increased evapotranspiration would result in increased consumption and increased diversion requirements for irrigated crops.

SECTION 4: VULNERABILITIES

A vulnerability assessment is the process of identifying the risk or susceptibility of a particular system. In drought planning it is a very useful tool for communicating among stakeholders to increase awareness, understanding, and ultimately identifying potential issues that are meaningful to stakeholders. A comprehensive assessment of the vulnerabilities completed at the appropriate scale, can also provide a framework for developing specific strategies to reduce or mitigate the identified risks. Currently, there is no best method or practice for conducting vulnerability assessments, and approaches in the literature vary depending on the objectives, scale, and scope. However, there is general agreement that vulnerability assessments should be integrative and multidimensional to best capture the inherent complexity and variability of drought vulnerability. Since one of the primary goals for drought planning in the Upper Missouri Basin is to empower local watershed coordinators to engage their communities in planning, but also link the watersheds into a cohesive plan, we adopted a multi-level qualitative approach to the vulnerability assessment portion of the plan.

During the early stages in training, we surveyed the drought coordinators and other partners that are familiar with the landscape to identify what they considered to be the areas of concern and potential vulnerabilities in their watersheds. Each of the drought coordinators used this training to employ their own techniques for engaging their respective water users to further identify risks and susceptibilities. Some of the watersheds were already comfortable with, or engaged in drought planning and could openly and readily solicit feedback from community members. However, in other watersheds the coordinators needed to enter the conversations carefully and rely on creative approaches. Many of them had one-on-one kitchen table interviews (Madison, Ruby, Centennial), held community forums (Upper & Lower Gallatin, Broadwater, Madison & Big Hole), or set up tables at community venues (like in front of the Post Office in Big Sky) to survey residents, generate interest and Initiate drought and water supply focus groups. Some of the watersheds also combined their drought planning with other similar efforts, such as in the Madison where they incorporated planning with developing a watershed restoration plan. In Big Sky, the drought planning was a subset of the much larger community effort known as the Big Sky Sustainable Solutions Water Forum, that addressed water supply, drought, wastewater, and ecological health of the river. As each of the coordinators gathered input from their communities, we created vulnerability tables that outlined the risks, challenges, and needs for their watershed. See Watershed Risks and Vulnerability, Table 9 below.

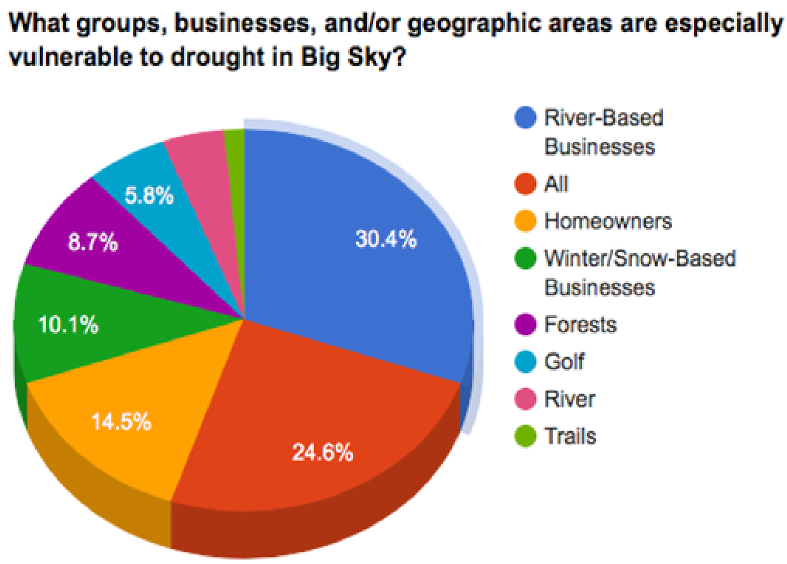

FIGURE 17 Results from the Drought Awareness Survey conducted by the Gallatin River Task Force in the Upper Gallatin.

TRIBUTARY WATERSHED	LOCALLY BASED GROUPS	GEOGRAPHY	ECONOMY	CHALLENGES & VULNERABILITIES
Beaverhead and Red Rock Rivers	Beaverhead CD, Beaverhead WS Committee, Centennial Valley Association	**Watershed Drainage:** 3,620 sq. mi. **Annual Flow:** 592,000 AF	• Mostly focused on agriculture and recreational interests. • ~55% of the land area is federally or state owned. • Beaverhead County is the #1 cattle producing and #3 sheep producing county in Montana. • Primary crops: alfalfa, hay, potatoes, spring wheat. • Angling and tourism	• Land use changes and management • Persistent drought over the past decade • Insufficient overwinter releases for fisheries out of Clark Canyon dam • Assessing relationship between soil health and drought resilience • Protection of fluvial arctic grayling and sage grouse • Water Supply monitoring and forecasting, especially inflows into Clark Canyon Reservoir • Agricultural Soil Health • Cloud Seeding in Idaho • Wildfire • City of Dillon Water System • Flood Risk for Subdivisions on Blacktail Deer Creek
Ruby River	Ruby Valley Conservation District, Ruby Watershed Council, Gravelly Landscape Collaborative	**Watershed Drainage:** 965 sq. mi. **Annual Flow:** 216,000 AF	• Livestock production primarily summer pasture on public land in the upper watershed • Recreational fishing, with several fishing lodges and two fly rod manufacturers in Twin Bridges • Mining	• Dewatering of tributaries • Stream-floodplain disconnection • Degradation of riparian areas • Irrigation conveyance • Competing needs between agriculture and fishing sectors • Previous droughts caused wildfire, reduced stream flows, and reduced water quality and soil health • Sedimentation in Ruby Reservoir, decreasing total capacity

TABLE 9 HUC 8 Watershed Identified Risks and Vulnerabilities *(continued on pp 42-43)*

TRIBUTARY WATERSHED	LOCALLY BASED GROUPS	GEOGRAPHY	ECONOMY	CHALLENGES & VULNERABILITIES
Big Hole River	Big Hole Watershed Committee, Big Hole River Foundation, Beaverhead, Mile High & Ruby Valley CDs	**Watershed Drainage:** 2,500 sq. mi. **Annual Flow:** 817,000 AF	• Agriculture: Ranching and Cattle production • 70% public ownership and 30% private • Recreational fishing-blue ribbon trout stream • Fewer than 2,000 year-round residents	• Chronic dewatering • Last remaining population of Fluvial Arctic Grayling in the lower 48 • Voluntary drought management plan in place since 1997 for the Upper sections of the river, need to expand to the lower sections • Conflicts between water users • Lower Big Hole River Irrigation Infrastructure • Big Hole River Section V DMP Triggers- based on the river's wetted perimeter, and not on the lower inflection point. • Wise River Flows- geologically constrained, with flows supplementing groundwater above the mouth and then returning downstream in the Big Hole. • Cross Basin Transfers of irrigation water from the Big Hole River that flow into the Beaverhead Basin. • Long term stream gage funding and coordination • Wildfire
Jefferson and Boulder Rivers	Jefferson River Watershed Council, Lower Jefferson Watershed Council, Jefferson & Ruby CDs	**Watershed Drainage:** 2,445 sq. mi. **Annual Flow:** 120,000 AF	• Agriculture • Recreational fishing. • Open pit gold mining	• Maintaining flow to support the ecosystem, and the fishery in particular • Changes in land and water uses • Aquatic invasive species • Coordinating information among the tributaries • Increasing fire potential: -Public health and exposure in the wildland urban interface • Economic vulnerability: -Fisheries recreation, - • Camping along river and access to land to utilize • Social relations: -Subdivisions and irrigation allotments • Lack of inflow controls to the Jefferson • Ecological resilience: -Range conditions & forage health • Water temperature vulnerability • Weed issues: -Timing and intensity of precipitation drives increase in Cheatgrass • Ecological response from sedimentation: -High sediment loads end up in low velocity areas (Jefferson Slough)
Madison River	Madison CD, Madison River Foundation, Madison Valley Ranchlands Group, Wildlife Conservation Society Community Partners Program	**Watershed Drainage:** 2,510 sq. mi **Annual Flow:** 1,310,000	• Agriculture • Tourism • Recreational Fishing • Abundant wildlife • Proximity to Yellowstone NP	• Development • Conflicts and increased pressure from recreational users • Changing land and water use • Chronic dewatering • Nutrient overload • Irrigation conveyance and infrastructure • Ice jams • High percentage of absentee landowners

TRIBUTARY WATERSHED	LOCALLY BASED GROUPS	GEOGRAPHY	ECONOMY	CHALLENGES & VULNERABILITIES
Gallatin River	**Upper:** Gallatin River Task Force **Lower:** Greater Gallatin WS Council, Gallatin Valley Land Trust, Association of Gallatin Irrigators, Gallatin CD, and City of Bozeman	**Watershed Drainage:** 1,800 sq. mi. **Annual Flow:**	**Upper:** • Tourism, skiing, golfing • Blue-ribbon fly-fishing destination • Big Sky Resort, amenity owners • Proximity to Yellowstone NP **Lower:** • Agriculture • Montana State University • Retiring Baby Boomers	**Upper Gallatin:** • Big Sky Resort Development reliant on snowpack • 2 Counties, no incorporated municipal government • Isolated mountain geography • Rapid rate of development, increasing tourism and recreational pressure • Climate variability and drought • Changes to in-stream flows, riparian habitat, and wetlands • Ground water/surface water connections, as well as landscape connectivity • Fisheries, wildlife, recreational opportunities, and impacts • Extensive amounts of private land and absentee landowner management of lands • Conversion of wild land to residential lawns **Lower Gallatin:** • Unprecedented growth, strains on municipal water supplies • Changing land use from agriculture to subdivisions, impacting historic irrigation infrastructure • Chronic Dewatering
Mainstem Missouri between Headwaters Confluence and Canyon Ferry	Broadwater Conservation District		• Agriculture • Recreation on Canyon Ferry Reservoir and nearby mountains • Bedroom community to state Capitol	• Vulnerability of agricultural production is based on spring moisture, snowpack and expected water supply for irrigation. • Recreational vulnerability high due to fluctuating Canyon Ferry reservoir levels and Missouri river flows. • Tributary streams are vulnerable • Municipal vulnerability is limited due to groundwater sources • Stock water • Overflow development pressure from Gallatin Valley

ASSESSING DIFFERENT TYPES OF DROUGHT & RISKS

Unlike other, more obvious disasters, drought is insidious and less apparent until it hits. Drought is typically classified in climatic terms, either meteorological, hydrological, or it is based on economic or socio impacts. However, in the intermountain west, where water is naturally in short supply, poor planning can also create human-induced water shortages, especially in rapidly developing areas. As stated in the City of Bozeman Drought Management Plan

"While drought is a widely-used term, there is no single universally-accepted definition of drought. From a meteorological perspective, drought is defined as an extended period of below average precipitation for a given region. Hydrologic drought refers to reduced stream flows, reservoirs, lakes, and groundwater to below-normal levels and tend to lag behind the onset of low precipitation due to the buffering effects of soil moisture, groundwater, and snowpack. Droughts are most often discussed from this perspective when water shortages begin to impact people in terms of water supply, loss of hydropower production, loss of fisheries, agricultural production losses and food shortages. Thus, drought is most commonly thought of as an interplay between climate and water-dependent processes. Often, drought is defined by its effects rather than its causes."

Thus, the concept of planning for drought has traditionally focused on how to identify the risks to ultimately reduce the associated impacts. Since agriculture depends heavily on a reliable water supply, it is the economic industry that has typically seen the most severe impacts when water is scarce. In specific areas of the Upper Missouri Basin, such as Big Sky, the Gallatin Valley and the overflow areas in southern Broadwater County and the Madison Valley, growth and development are having a dramatic impact on the legally available water supplies and setting up potential challenges between development, agriculture and recreational water users. Each of these watersheds is creating unique approaches to planning for their future water supply vulnerabilities.

ECOLOGICAL DROUGHT VULNERABILITY FRAMEWORK

Historically, droughts were natural events that shaped ecological processes and evolutionary adaptations, but anthropogenic disturbances are pushing the coupled natural-human systems beyond their adaptive capacity and triggering socioecological impacts, also known as ecological drought. If a system is pushed beyond its capacity to recover then it will begin to function differently, thereby impacting the critical ecosystem services that it provides for the human and natural community. Ecosystem services that can be impacted include water storage and filtering capacities, healthy soils, forests, rangeland, and riparian areas, changes in species composition increased fuel loads and wildfires.

Ecological drought, defined as "an episodic deficit in water availability that drives ecosystems beyond thresholds of vulnerability, impacts **ecosystem** services, and triggers feedbacks in natural and/or human systems" is a relatively new concept in the field of understanding droughts. During the drought planning process in the Upper Missouri Headwaters, we partnered with a national team of scientists, Science Nature and People Partnerships (SNAPP) EcoDrought team, to develop and test an innovative new concept to assess ecosystem vulnerabilities. The idea is to consider drought in terms of the interrelatedness of human and natural dimensions to better understand the impacts of drought on ecosystems, with the end goal to highlight opportunities for mitigation and/or adaptation strategies. As stated in the Bulletin of the American Meteorological Society,

"To prepare for the rising risk of drought in the twenty-first century, the drought conversation needs to be reframed by underscoring the value to human communities in sustaining ecosystems and the critical services they provide when water availability dips below critical thresholds. In particular, defining a new type of drought-ecological drought- that integrates the ecological, climatic, hydrological, socioeconomic, and cultural dimensions of drought. Ecological drought is defined as an episodic deficit in water availability that drives ecosystems beyond thresholds of vulnerability, impacts ecosystem services, and triggers feedbacks in natural and/or human systems" (Crausbay and Ramirez, et al.).

To better understand drought and the impacts on ecosystems, assessing vulnerability is based on three interrelated components; **exposure**, meaning the amount of ecologically available water during drought; **sensitivity**, which refers to the natural system's susceptibility to drought; and finally **adaptive capacity**, or the ability of a system to respond or cope with drought. The human and ecological interactions are depicted in Figure 18.

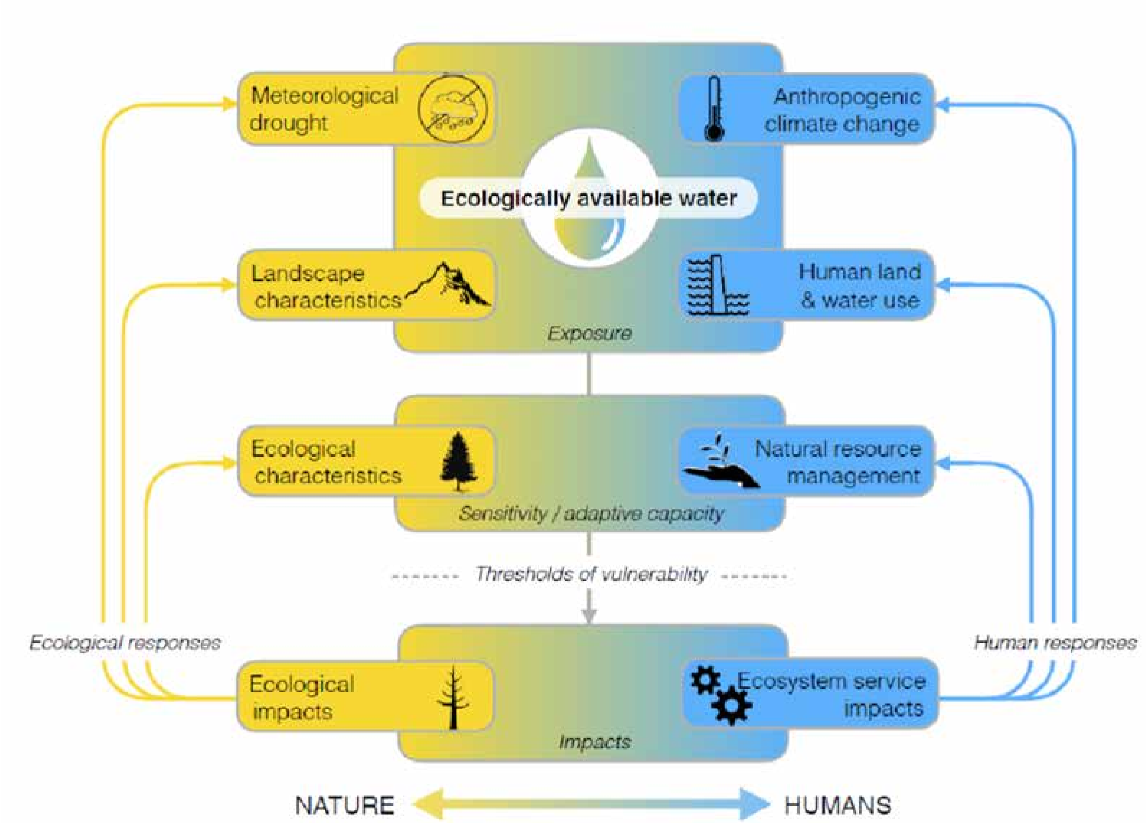

FIGURE 18 Conceptual diagram of ecological drought in the 21st century. This diagram illustrates the key drivers of drought vulnerability and impacts in coupled natural-human systems. Vulnerability = Exposure + Sensitivity + Adaptive Capacity. Curved arrows indicate feedbacks where ecological responses and changes in human behavior or institutions can alter ecological drought vulnerability. The yellow-blue color gradient represents the continuum of coupled natural-human systems. *From: Crausbay S*., Ramirez A*., and 17 others (2017). Defining ecological drought for the 21st century. *Co-first authors. Bulletin of the American Meteorological Society.*

The SNAPP EcoDrought team led a workshop in Bozeman, Montana, to further refine and test the methods to assess ecological vulnerabilities. The team also conducted personal follow-up interviews with many natural resource partners (agencies, drought coordinators, local decision-makers) to further flesh out perspectives on drought in the Basin. Since it is difficult to consider ecological drought in a very large context, the participants were divided into breakout sessions to focus on specific ecoregions, namely, forest, rangelands, and riparian areas. The groups discussed the potential vulnerabilities and consequences to people and nature during ecological drought. Using a holistic approach that incorporates both the human and natural communities can lead to more informed adaptation strategies and a better understanding of the potential multifaceted consequences and impacts. This process will help the communities create a more comprehensive drought response plan and be better prepared before drought occurs. The table below outlines the potential risks and impacts to ecosystems during a drought. While it is not an exhaustive list, it does provide a different perspective on how drought may indirectly affect both socio economic and natural systems. See Table 10.

POTENTIAL CONSEQUENCES TO PEOPLE AND NATURE

FOREST SYSTEMS	RANGELAND SYSTEMS	WETLANDS, STREAMS & RIPARIAN SYSTEMS
Changes in property values/ insurance costs	Negative impacts to grassland birds, sage grouse, songbirds, Sandhill cranes, pheasants	Shifts in macro-invertebrates
Loss of property	Impacts to the local economy/ grazing/haying	Harmful algal blooms
Decreased air quality	Reduced grassland bird populations for hunting	Impacts to recreation economy income
Increased fire suppression costs	Loss of forage and changes in soil health (e.g., increased compaction), with consequences for ranching livelihoods	Habitat management changes = ESA Section 7
Changes in local economy (boosts from suppression, costs from fires)	Decreases in pollinators & insect populations	Change in life history support for various species (and habitat connectivity)
Livestock/grazing range/economic fitness	Reduced Livestock grazing/ economic impact to ranches	Impacts to cultural identity of the region
Changing political discussion to justify logging	Increased fire risk	Increase in invasive species
Changes in landscape connectivity	Loss of springs (due to drying, but also development)	Increased pollutant concentration, warmer temperatures, lower dissolved oxygen
Potential increase in invasive species	Changes in impervious surfaces (loss of vegetation, increased compaction, less aquifer recharge)	Decreased water provisioning
Wind erosion/soil loss/increased flash flooding	Encroachment of junipers and other conifers (although increased fire frequency might reduce conifer encroachment)	Increased sediment may lead to changes in channel flooding
Changes in species composition	Increased invasive plants (especially cheatgrass), with subsequent changes to the fire regime	Reduction in visual quality (relates to cultural identity/services)
Short-term habitat loss, with effects on wildlife (e.g., elk & deer)	Decreased forage for wild ungulates	Larger fires due to losses of natural fire breaks (e.g., wetlands and riparian areas)
Erosion and sediment deposition in streams	Shifts in grassland plant species	Loss of diversity in habitat, species, genetics
Changes in water yield, timing	Need for increased herbicide use, with negative consequences for water quality	Decreased groundwater storage, drier "sponge"
Very hot temperatures can damage/ sterilize soils	Increased nutrient inputs from agricultural lands could lead to persistent change in aquatic ecology	Public health impacts (GW) à could link to nutrition
Loss of hydrological function can ripple into other ecosystem effects	Increased erosions, overland flow of sediments and nutrients	Changes in crops – shift to dryland farming; less barley, more hay
Fire could catalyze ecological transformations	If ranching becomes more difficult with increasing drought, may be a shift in the state's economy	Changes in streamflow timing
Long term: More positive – normal disturbance, regeneration, aid adaptation by clearing landscape, more resilient	Biofuels pose a risk	Loss of wetlands à has an effect on regulating flows, and loss of contributions to baseflows
Easier to manage post disturbance (e.g., Aspen coming back in Centennials)	Increased invasive species may lead to a loss of native species	Might be changes in human movement/ migration into the region (due to impacts in other regions) or out of the region
Sagebrush storing more snowpack (i.e., potential vegetation changes leading to hydrological changes)	Increased fire could lead to increased erosion and decreased water quality (especially in municipal drinking watersheds)	Changes in soil moisture could alter plant species and make them less resilient

TABLE 10 Potential risks and impacts to socioeconomic and natural systems during a drought.

Lower flows and higher air temperatures are leading to warming of streams and rivers that feed the Upper Missouri River. *Jon Catton photo.*

SECTION 5: MONITORING

Monitoring for drought in the Upper Missouri relies heavily on partner agencies, such as the US Geological Survey (USGS) stream gage network for measuring real time and historic discharge (cfs) on the larger streams, the MT DNRC's state based stream gage network for some of the smaller tributaries, the Natural Resources Conservation Service (NRCS) Snotel sites for snow accumulations, BOR and DNRC for reservoir levels and the National Weather Service. All of this information is monitored at the local, state, and national levels.

Within Montana we are fortunate to have the Governor's Drought and Water Supply Committee (DWSAC), that meets monthly during the irrigation season to continually monitor conditions, discuss, prepare, and respond to statewide drought emergencies. There is also a drought monitoring subcommittee, comprised of representatives from the above agencies that closely monitor conditions across the state to make collaborative recommendations for updates to the National Drought Monitor. The recommendations are based on reports and data collected from the agencies, and "ground-truthed" through the Drought Impacts Reporter that is hosted by our State Library System. Individuals from across Montana can provide first-hand accounts of the conditions in their region, thereby providing a more accurate assessment of local conditions. Montana is a large state and creating a comprehensive system of snowpack, streamflow, weather, and soil moisture monitoring from the mountain peaks to the prairies requires a coordinated effort across all agencies and water users.

While the monitoring is not necessarily interesting to everyone that lives in the Basin, this planning process has created a dedicated interest in better understanding and anticipating water issues. The drought coordinators compile and distribute regular water supply updates and reports to water users in their watersheds. The water supply reports are as individualized as the watersheds, but have led to a much larger public that is paying attention to conditions such as snowpack, spring runoff, soil moisture and the potential for extremely dry (or wet) conditions in the Basin. These reports provide a foundation to increase awareness of current and future water conditions, keeping potential drought in sight.

In addition to disseminating monthly water supply reports, the drought planning team collaborated with the US Fish and Wildlife Service GIS specialist, Matt Heller, to develop the River Conditions Tool. The

Big Sky Watershed AmeriCorps members are helping build community resilience in the Upper Missouri Basin. *Jon Catton photo.*

tool is based on a template created by the Big Hole watershed committee and is a web based "one-stop shop" for water users to view a variety of real time water related information in a single location. The River Conditions Tool is embedded on the Upper Missouri Headwaters website, as well as linked to and embedded on each of the watersheds' individual websites. The developer worked with the drought coordinators to divide their rivers into management sections that directly correlate with identified triggers in their drought response plans. The tool links directly to many resources, namely USGS stream gages, Snotel sites, DNRC stream gages, BOR and state reservoir information, Weather stations, BLM access sites, MT Fish Wildlife and Parks fishing access sites and closures, aquatic invasive species information, FEMA floodplain and channel migration maps. Visitors can view the Basin in its entirety on the main website, or link to the individual watersheds to zoom in on more specific details. Since all of the information is linked to the other data sites, updates occur automatically and provide real time information for water users, managers, and recreationists. It also provides a useful visual tool to monitor conditions in the surrounding watersheds, assisting the downstream drought coordinators in their management and response actions. The very successful RCT project is now expanding to other watersheds across Montana.

While the River Conditions Tool is extremely valuable, it is limited by the data that feeds into it. Most of the watershed coordinators indicate that the need for increased monitoring, especially stream gaging, is vital to their continued success in assessing and predicting impending drought and deteriorating water supply conditions. The increased awareness has led to a greater understanding of the existing limitations, and a desire to expand on long term data collection to accurately address and monitor the challenges. There is also great concern for the trend to decrease stream gage funding, particularly at a time when the data are crucial to implementing and measuring changing conditions. We cannot balance water supply and demand to develop viable solutions if we don't have an accurate accounting of the ever-changing water budget.

Volunteers plant willows to shade and cool a tributary to the East Gallatin River while also reducing sediment stresses on trout populations. *Jon Catton photo.*

SECTION 6: MITIGATION AND ADAPTATION STRATEGIES

Given that this is such a large area, and there isn't a single water authority for the entire region, mitigation and adaptation strategies were developed within each of the watersheds. While many of the approaches are similar, some are more specific to the water, environmental or socio-economic challenges that watershed is facing. The following table outlines the areas that the watersheds are working in to reduce their potential drought risks and vulnerabilities.

MITIGATION OR ADAPTATION STRATEGIES
Measure Clark Canyon Dam (CCD) inflows to improve water supply forecasting
Evaluate management alternatives to improve CCD overwinter releases for Beaverhead fishery
Develop an agricultural soil health demonstration project
Research effects of cloud seeding on downwind hydrology
Explore the potential of natural water storage through floodplain and stream channel restoration and beaver mimicry structures
Evaluate streams in the Basin for solar insolation and cold-water storage potential
Work with partner agencies to reduce wildfire risk
Support proposed mitigation actions from other local plans: City of Dillon water system; Beaverhead County pre-disaster mitigation plan; and BLM's Dillon Resource management plan.
Develop a City of Dillon Water Conservation Plan
Support Sage Grouse Initiative for protecting Sage Grouse habitat in the Beaverhead WS
Integrate the Beaverhead Watershed Restoration Plan

TABLE 11 Mitigation or adaptation strategies in use to reduce their potential drought risks and vulnerabilities *(continued on pp 50-51)*

MITIGATION OR ADAPTATION STRATEGIES
Support education, information dissemination, collaboration among stakeholders, and connect partners, technical expertise, and potential funding sources to encourage voluntary actions
Education and Information Sharing: hydrologic data (water reports) throughout the growing season, snow reports during the winter; community informational and exchange meetings
Integrate and support existing plans such as the MT State Water Plan and the NRCS Sage Grouse Initiative
Upgrade existing irrigation infrastructure and off-stream livestock watering
Increase natural water retention, such as beaver analog structures
Reduce conifer encroachment on the sagebrush steppe
Establish Red Rock Candidate Conservation Assurances with Agreements (CCAA) with landowners (similar approach as Big Hole WS) for protection of Fluvial Arctic Grayling
CVA serves as a facilitator between landowners and agencies to improve communication and coordination for drought awareness and mitigation actions
Develop and Implement the Big Hole Forestry Cooperative
Update irrigation infrastructure prioritization and complete remaining projects
Update the Big Hole watershed restoration plan
Support proposed mitigation actions from other local plans
Identify and implement stream and floodplain restoration projects including California creek restoration, French Gulch and Moose Creek restoration, Lower French Creek restoration, and Oregon Creek
Protect riparian corridors through the Big Hole river incentive program
Continue to support and update the Channel migration zone and floodplain mapping projects
Wildfire Mitigation projects
Work with private landowners through the continued support of the upper Big Hole Arctic Grayling Candidate Conservation Agreement with Assurances (CCAA) program
Participate in identifying long-term funding solutions with the Montana Stream Gage working group
Adjust Big Hole river drought management plan Section V flow triggers and add Wise River section
Respond to designated angling restrictions and river closures as designated by MT FWP
Coordinate with local and federal agencies on Wildfire response
Support adaptive grazing management strategies on public lands during drought
Convene Drought resilience stakeholder meetings to assess snowpack and water source trends at the beginning and end of the growing seasons
Monitor the snowpack, stream gages and inflows to Canyon Ferry reservoir and provide monthly reports and more frequent communication to stakeholders as necessary
Continue to refine the voluntary shared shortage plan to maintain minimum stream flows in Deep Creek and expand to other tributaries in the watershed
Support the DES goals, projects and objectives outlined in the Broadwater County Pre-disaster mitigation plan to reduce impacts from severe weather and drought, and reduce the risk of wildfire
The drought coordinator will communicate and participate in the BOR spring operations meeting to inform local stakeholders of BOR's Canyon Ferry level projections and restrictions
Identify strategies to increase water storage and retention, including on and off farm management and efficiency strategies, and high flow aquifer recharge projects
Implement potential projects that slow the water down as it moves through the system, including beaver mimicry, maintaining healthy wetland and riparian corridors, and increasing riparian and floodplain connectivity
Encourage water conservation through median strip planting, increasing residential indoor and outdoor efficiencies, and extending current City of Bozeman conservation incentives to county residents

MITIGATION OR ADAPTATION STRATEGIES
Support forest management practices that enhance and protect water supplies
Integrate further drought planning with the targeted Gallatin Watershed Restoration planning
Understand and track the ecological health of river systems: Detailed understanding of trends and impacts to water quality, water supply, streamflows, groundwater recharge, riparian and wetland health, and instream habitat and fisheries is essential for tracking and evaluating progress
Expand Groundwater Modeling and Monitoring to accurately characterize the available water supply in the Big Sky area by generating seasonal outlook reports for groundwater supplies, modeling the impacts of various climate scenarios, modeling various withdrawal amounts, developing real-time data on groundwater and surface water, and developing a water balance to identify "targets" or "triggers" for action
Slow the flow of water through the watershed: Having sufficient water available during low-flow times of the year is essential for both the ecological health of the river systems and community health. This requires methods for slowing the flow of water through the groundwater, surface water and stormwater systems
Develop Strategies for Water Conservation to inspire community members to actively engage in water conservation to reduce groundwater withdrawals, maintain instream flows, and build resilience against changing climatic conditions.
Address existing impacts: Ongoing development, current and past land-use practices, and impacts from increasing recreational pressures have negatively impacted water quality, riparian and wetland health, and instream habitat and fisheries in some areas. Addressing these impacts and changing future management and community norms is critical to meeting stakeholder goals
Preserve and enhance high quality water resources: Maintaining and enhancing stream, riparian and wetland areas and ensuring the prevention of further cumulative impacts, will help maintain water quality, fisheries, wildlife and scenic values, and support the recreation-based economy.
Improve Stormwater Management to "slow the flow" of water through the system to provide for aquifer recharge and increased late-season streamflows, while also providing resiliency for changing climatic conditions.
Support the newly developed Big Sky Water Conservation Program that provides incentives and rebates for indoor water conservation (shower head- toilet-faucet replacements), outdoor water conservation (weather based smart controllers, rain sensors and sprinkler audits) and encourages water wise landscaping through certification of "Trout friendly" landscapes
Expand Wastewater Reuse options that benefit water supply, including Expanding Water Reuse for Irrigation, Developing Water Reuse for Snowmaking, and Investigating Shallow Groundwater Recharge
Develop Mitigation of Water Rights over the long-term. In the near-term, maintain an open dialogue with State agencies and senior water rights holders on water rights adjudication, modifications to the change process, and the potential implications of mitigation
Expand education and outreach in community and school events, develop a marketing campaign, promotional video and through the website
Implement stream restoration projects such as beaver mimicry structures to reduce stream incisement, reduce sediment, connect floodplains, and reduce temperatures
Identify irrigation infrastructure improvements such as failing headgates, automate systems, or construct gates that will divert water back to the river from ditches
Improve soil moisture and nutrient monitoring efforts
Increase the use of soil cover crops
Provide riparian zone protection, including hardened livestock access points
Provide education on different livestock grazing techniques
Engage with NRCS on soil health improvement strategies
Monitor flows and temperatures on tributary streams and reservoirs
Install remote stream monitoring equipment
Improve groundwater surface water monitoring in high density areas
Support prescribed burning and thinning to improve habitat and create defensible space
Install Zeedyk structures to encourage groundwater recharge, sediment capture and habitat
Assess water leasing opportunities to improve instream flows

MITIGATION OR ADAPTATION STRATEGIES
Encourage hunting, fishing, floating and canoeing to support local economy
Increase fishing outfitter engagement in drought planning
Bank early season flows to improve groundwater recharge
Address canal seepage in areas that are actively losing water and not returning to the stream within a reasonable time frame
Install off stream livestock watering
Educate homeowners on fire and flood risks and steps to take in the event of an emergency
Improve early season warning updates through the use of website (River Conditions Tool), social media, radio, email and phone communication
Review snowpack data and reservoir storages, identify and convey information to water users
Develop cumulative discharge analysis for upstream tributaries including: the Big Hole, Beaverhead and Ruby River flows compared to Jefferson river stream gage near Twin Bridges
Develop a comprehensive watershed restoration plan
Restore floodplain connectivity and improve wetland and riparian habitat function, including reduce streamside development; reduce or replace hardened banks with deformable structures; restore incised stream channels; and restore sinuosity to streams
Increase riparian shading through streamside plantings
Encourage ground cover through cover crop plantings and rotations
Work with producers to develop grazing management plans
Reduce the incidence of recreational private ponds
Improve irrigation conveyance systems through canal improvements or pipes where appropriate
Improve diversion systems to more accurately control and measure diverted water
Remove encroaching conifers in grasslands and riparian areas and restore the habitats
Develop an evaluation and monitoring plan to assess and implement adaptive strategies
Work with the Ruby Watershed Council, Conservation District and partners to update the Ruby Watershed Restoration Plan to develop regime-based water quantity and quality standards
Meet with water users groups and update the voluntary shared shortage agreements to account for changes to the water delivery system since "The Plan to prevent the dewatering of the Ruby" was developed in 1994.
Identify areas where delivery efficiencies and water measurement can be improved
Continue to support and expand the extensive tributary monitoring network
Install restoration projects to restore stream and floodplain connection to recharge shallow aquifers
Improve riparian areas and habitat
Consider the hydrologic implications of changing irrigation methodologies from flood to sprinklers
Work with the local communities to further assess their vulnerabilities to their community water supplies
Create a framework for proactively addressing the chronic dewatering in the Ruby
Coordinate with water users on the timing of stored water deliveries

A rancher touts benefits to her cattle operation and the health of a stream from fencing a portion of her pasture and installing water tanks. *Jon Catton photo.*

SECTION 7: DROUGHT RESPONSE ACTIONS

For this Drought Contingency Plan, the action items have been focused on training the local drought coordinators so that they can increase awareness and community preparedness, identify the potential risks and vulnerabilities, and then recommend and implement long term strategies to reduce those risks. The drought coordinators do not have any authority to specifically "respond" to drought, that responsibility falls to the state and federal agencies, such as Department of Emergency Services or the Farm Service Agency, to deliver some type of immediate actions or agricultural relief packages. Therefore, response actions for this plan are to create a unified, informed network of coordinators that are consistently monitoring and reporting on the conditions to better prepare communities to the onset of drought. The adaptation or mitigation strategies really provide the long game for creating resilience within the region that will hopefully reduce the incidence and severity of future droughts.

Communities such as Twin Bridges, Montana can be made safer through watershed-restoration projects that slow down water and reduce the destructive power of peak flows. Jon Catton photo.

SECTION 8: SYNOPSIS

The National Drought Resilience Partnership was the catalyst that focused drought planning resources in the Upper Missouri Headwaters region, but the funding provided through this Drought Contingency Planning grant was crucial financial support to allow the local drought coordinators to focus their efforts at the community level. This project has provided the impetus and framework for engaging local communities to identify where they are vulnerable and develop home grown strategies to reduce those risks. And then connect those plans to a larger vision of water management and planning across the Basin. All of the partners, starting with national and federal leadership, through the state down to the local communities, have created the basis for weaving together a network of resources to support the application of strategies and create the foundation for building resilience across this significant landscape. The relationships, the networks, the knowledge, and information exchange ensure that the communities have the basic tools and connections they need to tackle a changing water future in the region. This planning process has also spawned similar, locally led efforts throughout Montana that will better connect and integrate local plans to the Montana State Drought Plan Update.

Please visit the Upper Missouri Headwaters and the individual watershed websites for more detailed information.

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APPENDIX 1

DROUGHT WORKSHOPS PARTICIPANT LIST

LAST	FIRST	AFFILIATION	TITLE
Aber	Jesse	MT DNRC	MT Gov. Drought & Water Supply Advisory Committee Coordinator
Anevski	John	BIA Water Program	Branch Chief for Biological Resources and Conservation
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Brown	Zach	One Montana	Water Program Manager
Buckley	Alice	Future West	Program Manager/ Outreach Specialist
Burbach	Thor	USFS	Regional Hydrologist
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Davis	Liz	Madison River Foundation	Executive Director
Davis	Tim	DNRC Water Resources	Divison Administrator
Deheza	Veva	Associate, Physical Science Division	NOAA
Dodge	Ted	Jefferson River Watershed Council	Coordinator
Dolan	Larry	MT DNRC	UpMo Hydrologist
Downing	Jen	Big Hole Watershed Committee	Executive Director
Downey	Michael	MT DNRC	Water Planner
Durham	Dan	USDA NRCS	District Conservationist
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APPENDIX 2

LONG-TERM DROUGHT RESILIENCE

FEDERAL ACTION PLAN OF THE NATIONAL DROUGHT RESILIENCE PARTNERSHIP

MARCH 2016

THE WHITE HOUSE
WASHINGTON

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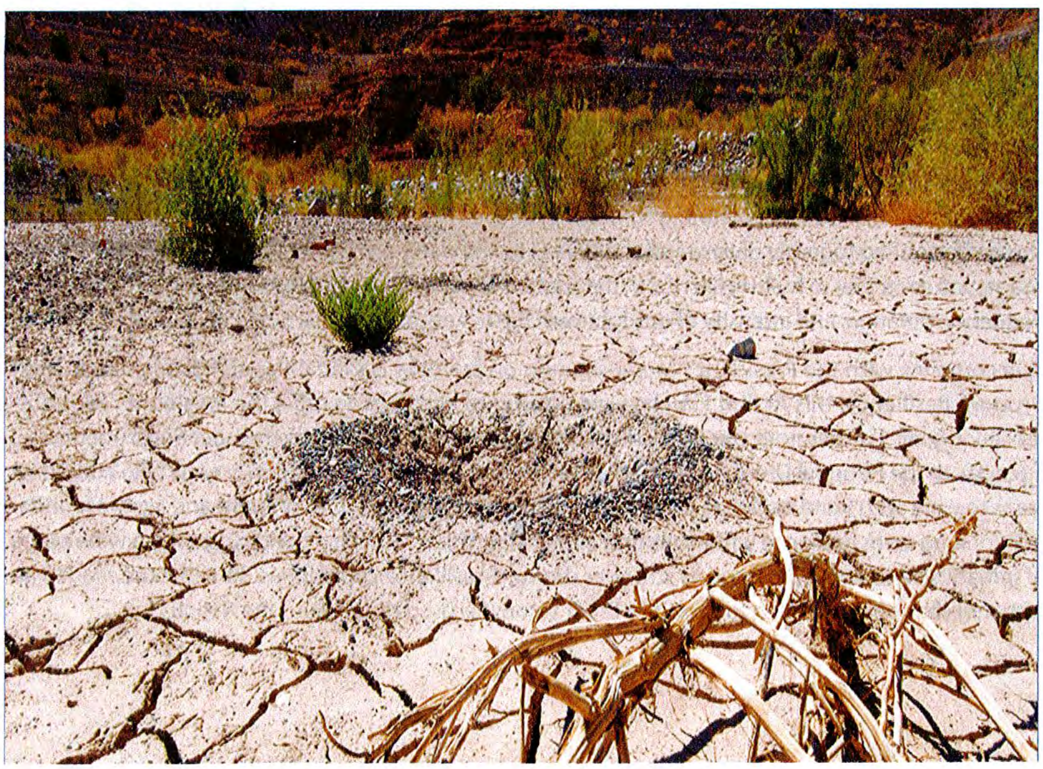
Introduction

Drought poses a serious threat to the resilience and security of communities nationwide and regularly impacts the lives of millions of Americans. Extreme, widespread drought challenges the security of the U.S. food supply and the integrity of critical infrastructure, causes extensive economic impacts, and increases energy costs. The impacts of climate change are expected to increase the frequency, intensity, and duration of droughts in many regions, and persistent drought could force foundational changes in the way communities use and live on the land. The economic impacts of drought can be extensive, with water-intensive industries potentially relocating and agricultural production shifting to other regions. The far-reaching effects of drought impact human and environmental health in many ways, due to factors including compromised water availability and quality, poor air quality, compromised food and nutrition, and increased incidence of illness and disease.

The Administration has built on long-standing drought-resilience initiatives led at the Federal, State, regional, tribal, and local levels to advance national-level drought-resilience capabilities. In doing so, the Federal Government has introduced new measures to anticipate and cope with drought by focusing on both short-term drought-response and long-term drought-resilience issues. In 2012, as part of the work of the White House Rural Council, the USDA led a National Disaster Recovery Framework effort to help communities respond to and recover from the 2012 drought. That effort involved a series of regional



listening sessions on how Federal and State agencies could collaborate to address regional drought risks. Additionally, the effort drew on previous work, such as the 2000 National Drought Commission Report, and ongoing work of the National Integrated Drought Information System (NIDIS). The NIDIS, relying on its network of government agencies and organizations, conducted drought outlooks around the country, and convened a National Drought Forum in partnership with State governors in Washington, D.C., in December 2012. The NIDIS continues to work across agencies and sectors to link drought monitoring, forecasting, and early warning with risk planning and management. President Obama signed the reauthorization of the NIDIS Act in 2014. He commended Congress for passing bipartisan legislation to ensure timely, effective drought early warning.

In 2013, as part of President Obama's Climate Action Plan, the Administration announced an interagency working group initiative, called the National Drought Resilience Partnership (NDRP) to help communities better prepare for future droughts and reduce the impact of drought events on livelihoods, health, and the economy. Recognizing that the Nation was facing more frequent and intense periods of drought, the NDRP sought to support State and local watershed-scale strategies for building long-term resilience, and to target their resources and expertise at appropriate regional scales. In doing so, State and local watershed-scale strategies are supported by the Federal government to help build a more drought-resilient nation.

The Federal Government can apply a range of authorities and resources for addressing drought. These include significant capacities in weather forecasting, data collection, and research; assistance with State, regional, tribal, and local drought-planning and water-management agreements; construction, operation, and management of water-supply infrastructure; investments in water-efficient energy systems; and programs that promote water-use efficiency and sustainable land and water management. In addition, the Federal Government has responded to stakeholder feedback by dedicating more attention to drought coordination and support of local planning. Federal agencies have also recognized the benefits of regional, watershed-level planning through initiatives like the WaterSMART Basin Study Program. These efforts bring together diverse stakeholders to assess water-supply risks and identify basin-specific adaptation strategies to build resilience. In the context of a changing climate, the likelihood of increased frequency, duration, and intensity of droughts will further necessitate this range of concerted action.

In accordance with the President's Memorandum on Building National Capabilities for Long-Term Drought Resilience, this Action Plan lays out a series of activities to fulfill the President's drought-resilience goals. Furthermore, this Action Plan outlines the ways in which the member departments and agencies of the National Drought Resilience Partnership can use existing resources to take additional steps to work with State, regional, tribal, and local partners to respond to drought and lay the foundation for long-term resilience within existing authorities. This Action Plan brings together a wide range of initiatives and concepts to build stronger drought-resilience capabilities. To assist the reader, an Appendix has been included to provide a list of acronyms used throughout the Action Plan.

Drought-Resilience Goals

Aligned with the President's Memorandum on Long-Term Drought Resilience, the goals laid out below—and their corresponding actions—are intended to help build national drought-resilience capabilities. The activities described in this Action Plan are intended to build on the President's directives in the aforementioned Memorandum. Additionally, these actions are intended to be undertaken in Fiscal Year (FY) 2016 or FY 2017 and will be carried out using existing resources and under existing authorities. As funding situations change, agencies will re-evaluate and re-prioritize their drought-resilience activities. The NDRP will update this Action Plan as needed to adapt to changing conditions and support an ongoing focus on building resilience to drought.

Goal 1: Data Collection and Integration

Goal 2: Communicating Drought Risk to Critical Infrastructure

Goal 3: Drought Planning and Capacity Building

Goal 4: Coordination of Federal Drought Activity

Goal 5: Market-Based Approaches for Infrastructure and Efficiency

Goal 6: Innovative Water Use, Efficiency, and Technology

Goal 1: Data Collection and Integration

Objective:

Agencies shall share data and information related to drought, water use, and water availability, including data on snowpack, groundwater, stream flow, and soil moisture with State, regional, tribal, and local officials to strengthen decisionmaking to support more adaptive responses to drought and drought risk.

Implementation Actions:

Integrate Existing Data and Information Sources for Regional-Level Use

1. **Integrate Data from Key Platforms:** Assess, strengthen, and connect existing space-based, airborne, and terrestrial data-collection and monitoring capabilities for water use and availability (e.g., capabilities at DOI-USGS, USDA, DOC-NOAA, EPA, NASA, and free and open data from the private sector). Major data-collection and monitoring capabilities should include capabilities for assessing: (1) groundwater, including quality and connections with surface waters; (2) soil moisture; (3) snowpack; (4) water use; and (5) surface water, including quality. Using principles of the Open Water Data Initiative, enhance the interoperability of information obtained through these capabilities with data obtained through surveys and reporting, to better characterize water supplies and drought-risk conditions, and to identify information gaps. Make data and information easily accessible to stakeholders in formats compatible for inclusion into existing geospatial data platforms. Integrate data on drought into health platforms, such as the Environmental Public Health Tracking Network.
    - **Lead Coordinating Agencies:** DOI-USGS, DOC-NOAA, USDA, and OSTP
    - **Supporting Agencies:** EPA, NASA, DOE, HHS-CDC
2. **Improve Modeling and Prediction:** DOC-NOAA will develop a national water-prediction capability at the National Water Center, which will support greater understanding of hydrologic science intended to strengthen observations, modeling, and forecasting. DOC-NOAA will also improve seasonal and sub-seasonal prediction for temperature, precipitation, and associated regional-information products.
    - **Lead Coordinating Agency:** DOC-NOAA
    - **Supporting Agencies:** DOI, EPA, NASA, USACE, DHS-FEMA, USDA

Enhance National Data Coverage

1. **Facilitate Citizen Science:** Provide guidelines and disseminate best practices and consistent protocols for crowdsourced data and other data collected through citizen-science initiatives related to water availability. The goal of this action is to foster solutions from a range of sources and to expand spatial and temporal data coverage. As an example, the Community Collaborative

Rain, Hail, and Snow rainfall network is expanding into tribal lands in the southwest, where available data are typically sparse. Data resources collected from these sources should be shared using principles of the Open Water Data Initiative.

- **Lead Coordinating Agencies:** DOC-NOAA and OSTP
- **Supporting Agencies:** DOI-USGS, EPA, NASA, USACE, DHS-FEMA, USDA

2. **Encourage Federal Reservoir Surveys:** Take advantage of drought-induced low reservoir levels to increase knowledge of the state of reservoir sedimentation. Identify and pursue ways to reduce the cost of reservoir surveys, and to share data from these surveys.
   - **Lead Coordinating Agency:** USACE
   - **Supporting Agency:** DOI-BOR

Develop Data Models to Identify Populations at Risk to the Health Effects of Drought

For selected infectious and non-infectious contaminants, develop predictive models that will identify highly vulnerable locations and populations in order to initiate protective measures. The health impacts of drought include infectious and non-infectious diseases as well as mental-health conditions. Models can help characterize the risk of these health impacts and can be used to plan for and respond to drought. Models will assess risks for non-infectious contaminants in well water (such as arsenic, nitrates, and uranium) that can change based on water level. Models will also predict locations vulnerable to drought-related infectious diseases, such as valley fever and hantavirus. Many of the issues associated with drought can occur after substantial periods of time, so long-term surveillance of these outcomes is required to accurately capture health effects.

- **Lead Coordinating Agency:** HHS-CDC
- **Supporting Agencies:** DOI-USGS, DOC-NOAA, NASA

Goal 2: Communicating Drought Risk to Critical Infrastructure

Objective:

Agencies shall communicate with State, regional, tribal, local, and critical infrastructure officials, targeted information about drought risks, including specific risks to critical infrastrucutre.

Implementation Actions:

Study Long-Term Drought Impacts on Critical Infrastructure

Conduct an in-depth study on the impacts of long-term drought on critical infrastructure. The study will examine the broad implications of a prolonged drought in California, based on a hydrological drought scenario of a five-year extension of drought conditions. This effort will be conducted in phases, in order to address highest-priority risks first, and results will be shared with State, local, and private-sector partners as results become available. The study will seek to identify potential strategies to mitigate and adapt to sector-specific long-term drought impacts to critical infrastructure. The study will help State, regional, tribal, local, and private-sector partners understand the risks of long-term drought to critical infrastructure.

- **Lead Coordinating Agency:** DHS-NPPD
- **Supporting Agencies:** DOC-NOAA, DOI, EPA, USACE, DOE, DOT, USDA

Create Drought Decision-Support Guides for Critical-Infrastructure Stakeholders

Use existing resources from USDA, DOI, DHS-FEMA, HHS-CDC, and EPA to compile sector-specific guides that provide technical assistance on how to protect and prepare critical infrastructures for the impacts of long-term drought. Leverage the experience of hazard-communication campaigns such as Ready.gov in effectively communicating with diverse stakeholder groups (including, but not limited to, the private sector; State, local, tribal, and territorial governments; the media; health departments and healthcare facilities; and the general public), to ensure the guides are effective in communicating risks and mitigation options to a wide range of drought stakeholders.

- **Lead Coordinating Agency:** DHS-NPPD
- **Supporting Agencies:** DOC-NOAA, DOI-USGS, EPA, USACE, DHS-FEMA, DOE, DOT, USDA, HHS-CDC

Goal 3: Drought Planning and Capacity Building

Objective:

Agencies shall assist State, regional, tribal, and local officials in building local planning capacity for drought preparedness and resilience.

Implementation Actions:

Coordinate Planning and Capacity-Building Programs

Multiple Federal agencies, including EPA, USDA-NRCS, and DOI, have programs to facilitate or support locally led watershed-level planning. These agencies will enhance the existing drought-plan clearinghouse[1] with increased geospatial capabilities, making it easier to connect existing NIDIS sponsored Federal programs and enabling more effective sharing and coordination of State, regional, tribal, and local drought plans. This activity also involves increased coordination of drought planning in hazard-mitigation strategies.

- **Lead Coordinating Agency:** DOC-NOAA
- **Supporting Agencies:** DOI, USDA, DHS-FEMA, EPA, USACE

Examine the Ecological Impacts of Drought Across the United States

The DOI-USGS will lead a study with Federal, academic, and non-profit ecological-sciences experts to synthesize the current understanding of drought impacts on ecosystems. This effort will lead to better-informed decisionmaking with respect to the regional effects of drought on wildlife and ecosystems; identify potential threats to valued resources; and prioritize research needs regarding the ecological impacts of drought. Additionally, the study will examine sets of management options that are relevant at the national, State, regional, tribal, and local levels.

- **Lead Coordinating Agency:** DOI
- **Supporting Agencies:** DOC-NOAA, USDA

Strengthen Rural Drinking Water Contingency Plans

USDA will work with States and tribes to identify rural communities most at risk for compromised drinking-water supplies as a result of drought, including those that are at risk as a result of depleted or contaminated groundwater. Additionally, USDA will make inclusion of drought-impact planning in

1. The clearinghouse is currently hosted by the National Drought Mitigation Center

emergency-response plans a condition of funding for new water and waste infrastructure projects. USDA will train technical assistance providers, as needed, to facilitate development and updating of vulnerability plans and emergency-response plans, and to ensure that plans include procedures for monitoring and reporting in order to evaluate conditions and rapidly conduct vulnerability assessments.

- **Lead Coordinating Agency:** USDA
- **Supporting Agencies:** DOI, EPA, DHS-FEMA, HHS-CDC

Support State, Tribal, Local, and Territorial Health Departments

Develop a drought-resource guide for health departments that focuses on planning for and responding to the health effects of drought. Expand existing work with State, local, tribal and territorial health departments to identify the health effects of drought; identify at-risk populations in those communities; and develop and implement activities to decrease the risk of drought-related health effects.

- **Lead Coordinating Agency:** HHS-CDC
- **Supporting Agencies:** DOC-NOAA, DOI, and USDA

Goal 4: Coordination of Federal Drought Activity

Objective:

Agencies shall improve the coordination and integration of drought-related activities to enhance the collective benefits of Federal programs and investments.

Implementation Actions:

Drive Coordination and Sharing of Information Related to Federal Investments in Water Infrastructure

Federal agencies will pilot, at the watershed, level an effort to compile and share information on federally funded grant and loan projects; non-sensitive application information for requested projects; and locations of planned infrastructure investments through creation of an information-sharing tool. This tool will be used by Federal officials to prompt collaboration among agencies by providing visibility on existing Federal investments and relevant pending applications within a watershed. The effort will consider public-facing options to support existing intact watershed-planning processes like the DOI Basin Studies. The criteria for inclusion of data in the tool shall be thoughtfully and carefully evaluated so as to not contradict Congressional action or the President's Budget.

- **Lead Coordinating Agencies:** DOI and USDA
- **Supporting Agencies:** EPA, USACE, DOC-EDA, HUD, DOC-NOAA, OMB

Extend Best Practices of Coordinated Federal Water-Resource Programs

USDA and DOI-BOR will extend the successful cross-program coordination practices from programs such as the DOI-BOR WaterSMART and USDA EQIP water-efficiency grants currently underway in California to other basins suffering from or at risk for drought. In 2011, DOI-BOR and USDA began a partnership to leverage funding for water-delivery agencies and agricultural producers in California. Through a competitive process, DOI-BOR makes funding available to irrigation districts and other entities so that improvements that save water or improve water management can be made in the systems that deliver water to farmers. USDA-NRCS, in turn, makes funding available to farmers who receive water from those districts so that on-farm conservation improvements can also be made throughout those districts.

- **Lead Coordinating Agencies:** DOI-BOR and USDA
- **Supporting Agency:** EPA

Launch a Prize Competition or Ideation Challenge

DOI is currently leading an FY 2016 effort with multiple agencies to help incentivize new technologies or scale up existing methods of water-use innovation through prize competitions and/or ideation challenges. Those efforts could be focused on complex and pressing water-related problems such as: (1) detecting and repairing leaks in water-conveyance systems; (2) forecasting drought and water supply; (3) managing desalination concentrate; (4) suppressing reservoir evaporation; and (5) investigating and proposing cost-effective solutions for grey water reuse in existing urban buildings. Explore opportunities to match prize competitors with Federal business-assistance resources to accelerate commercialization of promising solutions to the marketplace.

- **Lead Coordinating Agency:** DOI
- **Supporting Agencies:** USACE, USDA, NSF, NASA, DOC, EPA, SBA

Manage Federal Assets to Promote Local Drought Resilience

1. **Increasing Water-Management Flexibility:** Improve drought preparedness by developing and implementing new processes and considerations into reservoir management. Develop and implement a new process for streamlining preparation, review, and approval of USACE Water Control Plan deviations. Deviations from an approved USACE Water Control Plan in certain circumstances can create opportunities to alleviate critical drought impacts consistent with legislated facility purposes. DOI-BOR will begin implementation of five pilot activities at DOI-BOR reservoirs. These pilots will explore both the tracking of water supplies affected by climate change as well as other reservoir operations opportunities. DOI-BOR will also coordinate with USACE in cases where storage is co-managed for water supply and flood control to identify opportunities to leverage deviation requests.
    - **Lead Coordinating Agencies:** USACE and DOI-BOR
    - **Supporting Agencies:** N/A
2. **Promoting Stronger Drought Resilience on Federal Lands:** Through work with water users and interagency efforts such as the Western Watershed Enhancement Partnership, foster public-private partnerships to address risks from wildfire, insects and disease, invasive species, and other risks impacting water availability in drought-prone regions. Continue to improve drought monitoring, forecasting, and response in Federal land-management programs and decisions.
    - **Lead Coordinating Agencies:** DOI and USDA
    - **Supporting Agencies:** EPA, USACE, DOC-NOAA

Enhance Federal Drought Resilience Investments at the Watershed Scale:

USDA-NRCS conservation programs targeted in a strategic manner, such as through the Regional Conservation Partnership Program (RCPP), create opportunities for partners to develop regionally appropriate strategies to address conservation challenges across the country, including challenges created by water scarcity. USDA-NRCS will encourage Federal agencies to join State, regional, tribal and local partners in drafting project proposals for innovative approaches to enhancing drought resilience on farms, ranches, and private forest lands. Applicants will be encouraged to submit proposals that build on other Federal, state, and private resilience investments—including those made through DOI's WaterSMART and EPA's State Revolving Loan programs—that fall within their proposed projects footprint.

- **Lead Coordinating Agency:** USDA-NRCS
- **Supporting Agencies:** DOI, EPA

Goal 5: Market-Based Approaches for Infrastructure and Efficiency

Objective:

Agencies shall support the advancement of innovative investment models and market-based approaches to increase resilience, flexibility, and efficiency of water use and water-supply systems.

Implementation Actions:

Explore Innovative Financing Options for Drought Resilience

Leverage the EPA Water Infrastructure and Resiliency Finance Center, the USDA Rural Opportunity Investment Initiative, and the DOI Natural Resources Investment Center to increase non-Federal and private investment in projects that increase drought resilience. This activity includes leveraging EPA State Revolving Loan Fund program funds to support efficient irrigation infrastructure; seeking contributed funds to increase investment in DOI-BOR assets; leveraging USDA rural water loans to generate new opportunities for private sector investment in rural water infrastructure that would provide co-benefits such as improved water supply, water quality and flood management; and working with municipalities and agricultural sectors to establish partnerships for conservation.

- **Lead Coordinating Agencies:** EPA, USDA, and DOI
- **Supporting Agency:** Treasury

Support State and Local Strategies for more Flexible Water Management

In many cases, States and local water users are exploring new strategies to increase water use flexibility during drought, including the use of water transactions. Given its water-management responsibilities, the Federal Government may have a role in enabling or facilitating those strategies. Identify strategies to facilitate water transfers and water banking to mitigate water shortages, including review of case studies on model projects and alternative administrative regimes. DOI will consider developing guidance to facilitate locally led water transactions and will promote best practices, where appropriate, at DOI-BOR facilities.

- **Lead Coordinating Agency:** DOI
- **Supporting Agencies:** EPA, USDA

Disseminate Information on Water Pricing and Construction Cost Repayments

Greater transparency about the per-unit price of water resourced from Federal reservoirs will better inform water users and the other market suppliers about current market pricing for Federally sourced water. DOI-BOR will raise awareness about the availability and accessibility of construction cost repayment statements.

- **Lead Coordinating Agency:** DOI-BOR
- **Supporting Agencies:** USDA, USACE

Goal 6: Innovative Water Use, Efficiency, and Technology

Objective:

Agencies shall support efforts to conserve and make efficient use of water by carrying out relevant research, innovation, and international engagements.

Implementation Actions:

Conduct Research to Optimize and Improve Agricultural Water Use

Convene a workgroup of technical specialists and managers from Federal, State, tribal, local, and academic institutions to identify and promote more efficient agricultural water use. The workgroup will: (1) identify key steps for optimizing agricultural water-use efficiency at the watershed scale while ensuring sustainable agriculture; (2) expand data collection to enable better understanding of agricultural-producer and irrigation-district responses to drought; (3) provide resources to develop the evidence base for understanding the socio-economic drivers of farm-level water use and response to water scarcity, drought risk, and climate variability; (4) develop a decision-support tool to build on this research findings to enable more effective engagement and utilization by agriculture communities; and (5) develop a plan for increasing adoption of technologies that enhance water use, reuse, and production efficiency.

- **Lead Coordinating Agencies:** USDA, NSTC-SWAQ
- **Supporting Agencies:** N/A

Conduct Research to Optimize and Improve Energy-Sector Water Use

Pursue research into technologies that reduce the need for cooling water in thermoelectric generation and related industrial processes. Develop a strategy, with stakeholder input from States and the private sector, to accelerate and improve the deployment of such technologies.

- **Lead Coordinating Agency:** DOE
- **Supporting Agency:** NSF

Conduct Research to Improve Performance and Reduce Energy Requirements and Carbon Emissions from Water-Treatment Technologies

Pursue research into technologies that reduce energy requirements and carbon emissions of water-treatment technologies in order to make alternate water resources more accessible. Publish findings from this research on the progress and advances in such technologies. The publications will highlight areas for future development and opportunities for deployment of such technologies.

- **Lead Coordinating Agency:** DOE
- **Supporting Agencies:** EPA, DOI, NSF

Highlight Resilience Successes from the Municipal Sector

Utilize the NSTC Sub-Committee on Water Availability and Quality to identify best practices and case studies that highlight municipal-level examples of effective planning, multi-sector collaboration, and financing for drought resilience. Identify common challenges and innovative solutions for how communities can implement effective drought-resilience initiatives. Highlight lessons learned and common challenges via a national platform in order to widespread adoption.

- **Lead Coordinating Agencies:** EPA, NSTC-SWAQ
- **Supporting Agencies:** DOC-NOAA, USDA, DOI, DOE

Establish a Soil Health Monitoring and Enhancement Network

Establish a network to provide information on soil health as a significant indicator of agriculture-related demand for water, and identify methods for improving soil health that could increase soil water-holding capacity. Provide guidelines for managing soil health and preventing future degradation. Use the soil-health information generated by the network to inform future investments that improve soil health.

- **Lead Coordinating Agency:** USDA
- **Supporting Agencies:** N/A

Develop Municipal Water-Recycling Technical Assistance

Building upon recently awarded research-grant funding, develop a series of technical-assistance documents that assist States, regions, tribes, and localities as they plan for future water-reuse and recycling projects. The technical-assistance documents will include topics such as: regulated or unregulated contaminants and expected presence in treated water; evaluation of common drinking-water treatment processes and their inactivation/removal efficiency; microbial, chemical, radiological, and emerging contaminants; recommended monitoring of influent and effluent for water-treatment plants; and recommended monitoring of finished water.

- **Lead Coordinating Agency:** EPA
- **Supporting Agencies:** USDA, DOI

Maximize Use of Existing Diplomatic Engagement Structures to Advance International Drought-Related Research and Collaboration

Engage with key countries and multilateral institutions to share best practices and research on drought with U.S. technical experts, through workshops, technical exchanges, and/or joint research leveraged through existing institutional arrangements and diplomatic efforts. Initial bilateral engagement began with Australia under the auspices of the Joint Commission Meeting on Science and Technology. Multilateral engagement can be pursued through United Nations (UN) specialized agencies such as the UN Educational, Scientific and Cultural Organization and the World Meteorological Organization, as well as other regional and global partnerships and initiatives. Knowledge gained and opportunities to engage will be shared with relevant experts within the United States through existing platforms such as the U.S. Water Partnership, the Global Water Research Coalition, and the National Integrated Drought Information System.

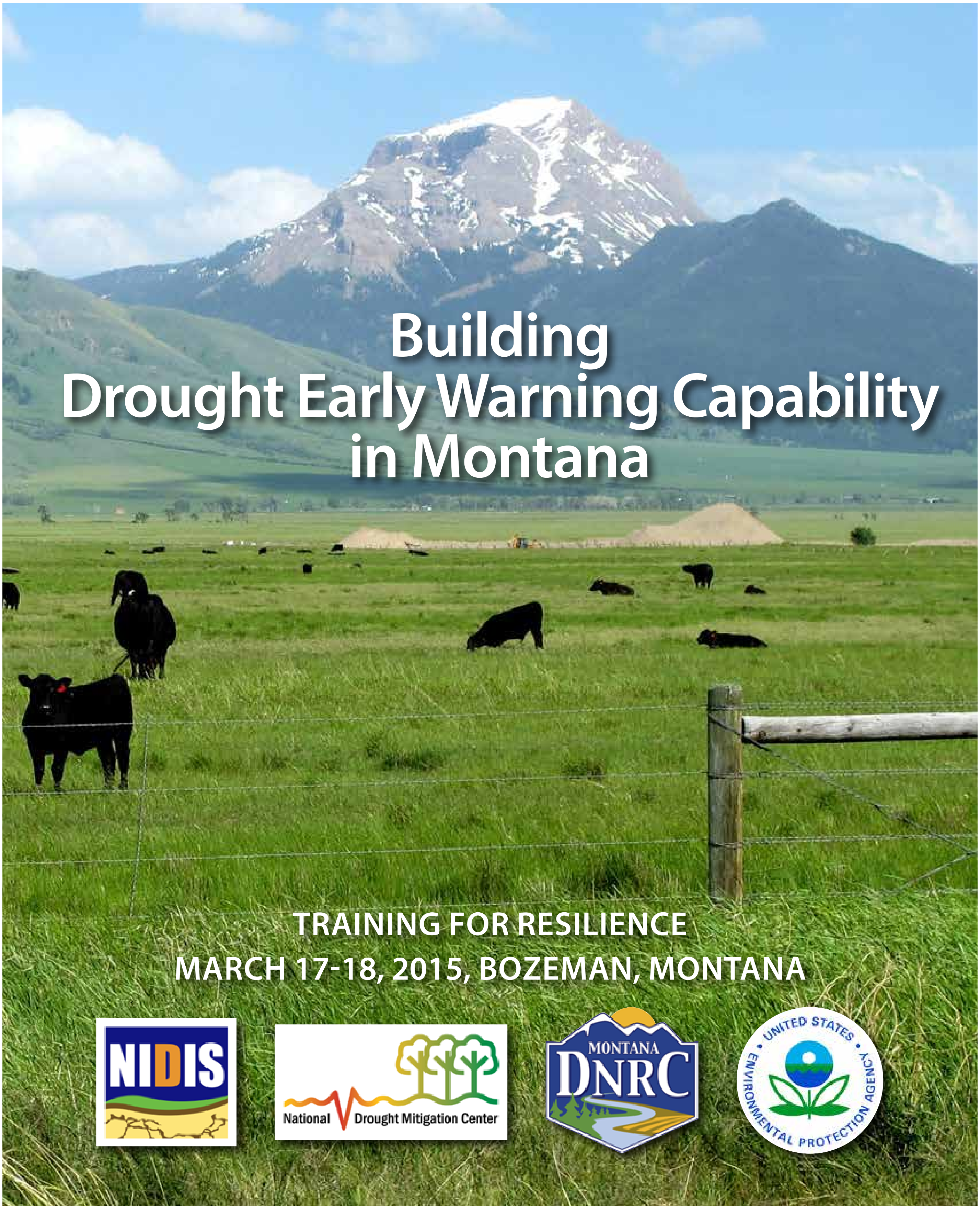
- **Lead Coordinating Agencies:** DOS, DOI, and USACE
- **Supporting Agencies:** DOC-NOAA, EPA, USDA, DOE

Appendix: List of Abbreviations

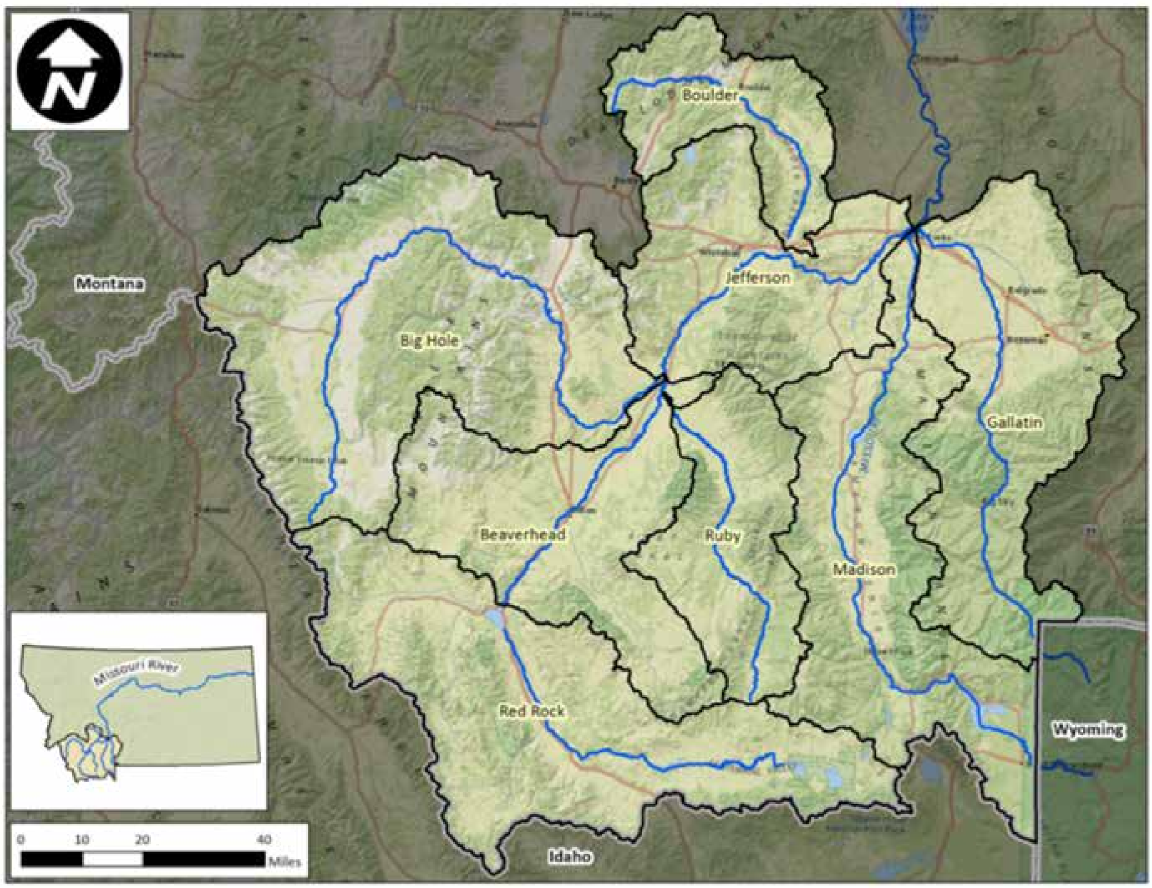
DHS	Department of Homeland Security
DHS-FEMA	Department of Homeland Security, Federal Emergency Management Agency
DHS-NPPD	Department of Homeland Security, National Protection and Programs Directorate
DOC	Department of Commerce
DOC-EDA	Department of Commerce, U.S. Economic Development Administration
DOC-NIST	Department of Commerce, National Institute of Standards and Technology
DOC-NOAA	Department of Commerce, National Oceanic and Atmospheric Administration
DOC-PTO	Department of Commerce, Patent and Trademark Office
DOE	Department of Energy
DOI	Department of the Interior
DOI-BOR	Department of the Interior, United States Bureau of Reclamation
DOI-FWS	Department of the Interior, U.S. Fish and Wildlife Service
DOI-USGS	Department of the Interior, United States Geological Survey
DOS	Department of State
DOT	Department of Transportation
EPA	Environmental Protection Agency
HHS	Department of Health and Human Services
HHS-CDC	Department of Health and Human Services, Centers for Disease Control and Prevention
HUD	Department of Housing and Urban Development
NASA	National Aeronautics and Space Administration
NDRP	National Drought Resilience Partnership
NIDIS	National Integrated Drought Information System
NSF	National Science Foundation
NSTC	National Science and Technology Council
NSTC-SWAQ	National Science and Technology Council, Subcommittee on Water Availability and Quality
OMB	Office of Management and Budget, The White House
OSTP	Office of Science and Technology Policy, The White House

RCPP	Regional Conservation Partnership Program
SBA	Small Business Administration
Treasury	U.S. Department of the Treasury
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USDA EQIP	U.S. Department of Agriculture, Environmental Quality Incentives Program
USDA-NRCS	U.S. Department of Agriculture, Natural Resources Conservation Service
USFWS	U.S. Fish and Wildlife Service
DOI WaterSMART	Department of the Interior, Water (Sustain and Manage American Resources for Tomorrow) Program

APPENDIX 3


Building
Drought Early Warning Capability
in Montana
TRAINING FOR RESILIENCE
MARCH 17-18, 2015, BOZEMAN, MONTANA
NIDIS
National Drought Mitigation Center
MONTANA
DNRC
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Building Drought Early Warning Capability in Montana



Map of the Upper Missouri River Basin, which was geographical region of focus for the meeting.

Sponsors

- NOAA's National Integrated Drought Information System (NIDIS)
- The National Drought Mitigation Center (NDMC)
- Montana's Department of Natural Resources and Conservation (DNRC)
- The Environmental Protection Agency (EPA)
- The effort helped support activities for the NIDIS Drought Early Warning System in the Missouri Basin, as well as functioning as a demonstration project for Montana announced by the National Drought Resilience Partnership (NDRP).

INTRODUCTION

Ivan Doig wrote, "We count by years, but we live by days." This is an analogy to droughts, in that we tend to think about them as singular events, yet we experience them by degrees, as they evolve, usually over an extended period of time. Droughts are a normal part of the climatic cycle and can occur in any climate regime around the world, including deserts and rainforests. It can be difficult to determine when they begin and when they end, and their impacts can extend over a larger geographical area compared to other natural hazards. Environmental changes involving incremental and cumulative problems usually receive little attention in their early phases, as decision and policymakers choose to deal with more immediate concerns. If these creeping events go unaddressed they can eventually become crises that are more costly to manage. A drought should never surprise anyone, yet it often does.

The Upper Missouri Basin in southwestern Montana has experienced frequent droughts. It is composed of the Madison, Gallatin, and Jefferson Rivers and their tributaries. Their confluence of the three rivers at Three Forks, Montana, forms the headwaters of the Missouri River. The Upper Missouri Basin is a mix of agricultural lands, scenic rivers with an active trout fishing industry, resorts, and a growing urban area in Bozeman. Each sector has unique needs and the desire to grow and sustain its activities. Ownership of land in the basin is a combination of private, state, and federal. Most lowlands are privately owned, while the U.S. Forest Service (USFS) or the Bureau of Land Management (BLM) administer most of the higher elevations.

THE WORKSHOP

Workshop participants gathered at tables set up for each of the headwaters areas.

On March 16-17, 2015, a workshop in Bozeman, Montana, brought together participants from across the Upper Missouri Basin to discuss ways to improve drought early warning and drought resilience. The participants came from seven sub-watersheds, which included the Beaverhead, Ruby, Big Hole, Upper Gallatin, Lower Gallatin, Madison, and Jefferson Rivers. The national Oceanic and Atmospheric Administration's (NOAA's)National Integrated Drought Information System (NIDIS), the National Drought Mitigation Center (NDMC), the Environmental Protection Agency (EPA), and Montana's Department of Natural Resources and Conservation (DNRC) hosted the meeting. The effort helped support activities for the NIDIS Drought Early Warning System in the Missouri Basin, as well as functioning as a demonstration project for Montana announced by the National Drought Resilience Partnership (NDRP). Over the course of the workshop, participants from the sub-watersheds examined tools that could be used to develop or strengthen watershed-specific drought plans. In addition to the overarching theme of drought, the workshop highlighted the opportunity to develop broader water management plans to reflect water shortages even in non-drought years.

The workshop was designed to bring together watershed-based "teams" that could initiate a conversation with the community on managing scarce water resources and preparing for future drought conditions. Workshop facilitators from NIDIS and the NDMC led the group in a step-by-step drought planning process using tools, such as the Drought Impact Reporter, the Drought Risk Atlas, and the Drought-Ready Communities guide, to track conditions, identify triggers and work through potential conflicts between water users. The diverse group of participants included Big Sky Watershed Corps (BSWC) AmeriCorps members, watershed coordinators, state and local agencies, city planners, agricultural producers, land trusts, conservation districts, NGOs, hydrologists, and local federal partners.

Agenda

DAY 1: Identifying Impacts, Risks, Vulnerabilities, and Drought Monitoring Resources

- Overview of Drought Planning and Risk Management
- Identifying Drought Planning Resources
- Introductions to NDMC, NIDIS and the Missouri Basin Regional Drought Early Warning System; Montana State Drought Plan, Drought Advisory Committee and State Climate Office
- Identifying and Assessing Your Impacts and Vulnerabilities: The Drought Impact Reporter (http://droughtreporter.unl.edu/)
- Identifying Your Drought Risk: The Drought Risk Atlas http://droughtatlas.unl.edu/)

DAY 2: Framing a Plan

- Drought Monitoring and Early Warning Resources: The U.S. Drought Monitor and other tools
- Identifying Monitoring and Early Warning Needs
- Framing Your Drought Plan
- Identifying Opportunities for Implementation of Mitigation Strategies
  - How to Implement Your Plan

Participants

- Big Sky Watershed Corps (BSWC) AmeriCorps members
- Watershed coordinators
- State and local agencies
- City planners
- Agricultural producers
- Land trusts
- Conservation districts
- NGOs
- Hydrologists
- Local federal partners

Representatives came from seven sub-watersheds of the Upper Missouri Basin, which include the Beaverhead, Ruby, Big Hole, Upper Gallatin, Lower Gallatin, Madison, and Jefferson Rivers.

About the pre-workshop survey

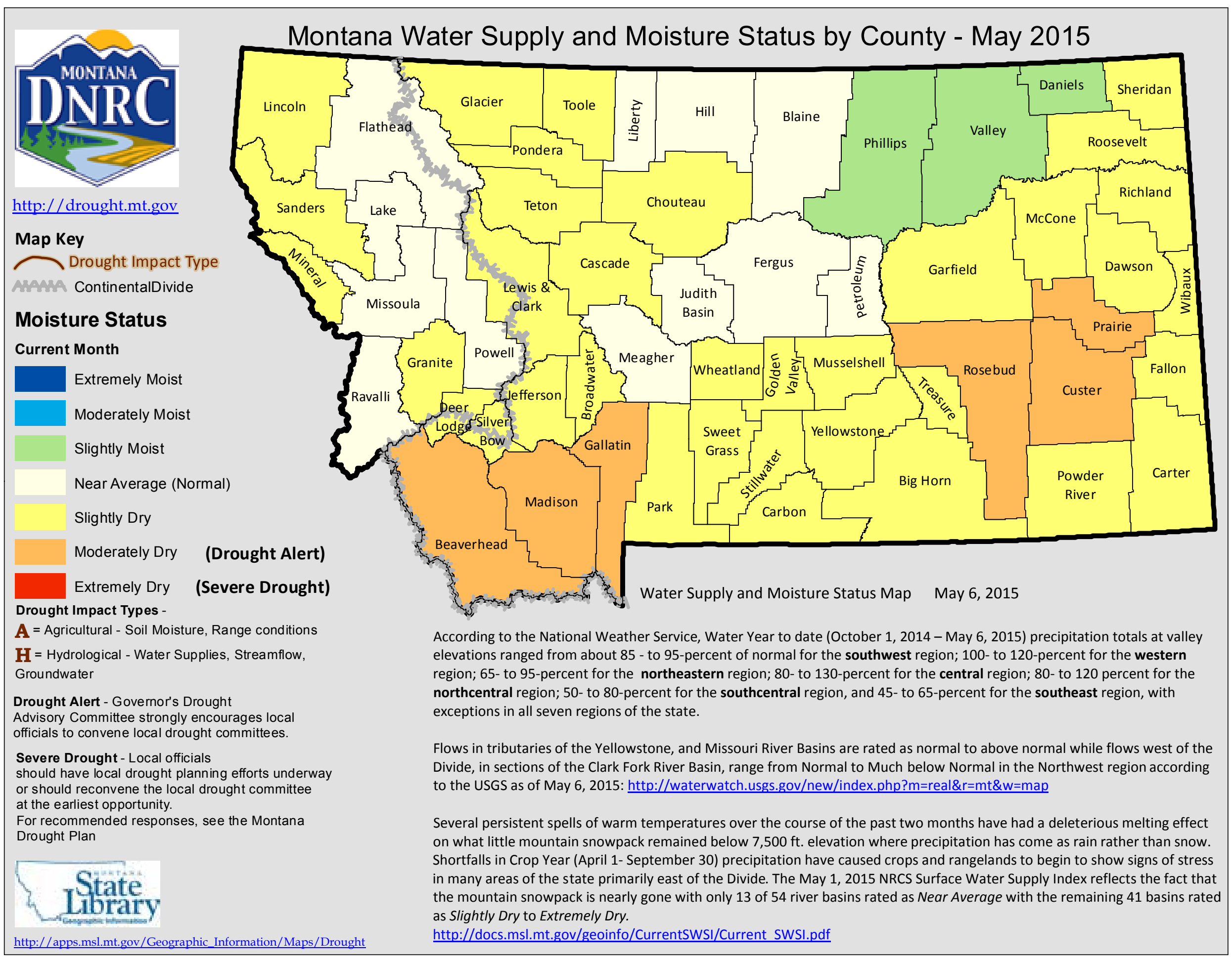
Before the workshop, a survey was sent to all of the expected participants. The results guided the workshop agenda and informed the discussion questions. Excerpts from the results appear as sidebars in this document.

A post-workshop survey was also conducted to assess the applicability of the material presented, what the participants learned at the workshop, and how the information would be applied in their respective watersheds. A summary of the findings is presented on pages 18-19.

MONITORING AND FORECAST GROUPS AND RESOURCES

The first part of the workshop consisted of describing existing resources available for observing, monitoring, and forecasting conditions related to drought. Four organizations were highlighted that either produce or help consolidate the data and information related to drought monitoring and early warning. Specific examples of data products were given in the context of each group. The organizations were:

- ✦ **The National Integrated Drought Information System** (NIDIS) is an interagency federal program created by Congress in 2006 to develop a drought early warning system (DEWS) for the U.S. NIDIS is working toward its national goal by establishing a network of regional DEWS (RDEWS). These RDEWS build on existing monitoring and forecast products and service networks like the U.S. Drought Monitor (USDM) and seasonal outlooks (e.g. the National Weather Service's Climate Prediction Center 90-day



The Water Supply and Moisture Status Map is a key index for the Montana Governor's Drought and Water Supply Advisory Committee. It is produced by Committee and published by the Montana State Library. The library also archives the maps back to 2002: http://mslapps.mt.gov/Geographic_Information/Maps/drought/

seasonal outlook) to provide improved communication and coordination of monitoring, forecasting, and impact assessment at national, watershed, state and local levels. One example of this work is the Missouri River Basin RDEWS (http://www.drought.gov/drought/regional-programs/mrb/missouri-river-basin-homee) that was initiated in early 2014 and encompasses the watersheds that participated in this workshop. NIDIS is housed within NOAA.

- **The National Drought Mitigation Center (**NDMC) established in 1995, is based in the School of Natural Resources at the University of Nebraska-Lincoln. The NDMC's activities include the production of drought monitoring information and products. For example, NDMC, along with NOAA, and the U.S. Department of Agriculture (USDA), lead the preparation of the U.S. Drought Monitor (USDM). The NDMC has also developed the U.S. Drought Impact Reporter and the Drought Risk Atlas (both described below); a suite of web-based drought management decision-making tools; drought planning and mitigation guides; K-12 outreach; and helps organize workshops for federal, state, foreign governments and international organizations.
- **The Governor's Drought and Water Supply Advisory Committee** was established by an act of the Montana State Legislature (MCA Sec. 2-15-3308 Drought Advisory Committee) in 1991 following a series of drought years in the 1980s. The primary purpose of the act was to create a state drought advisory committee composed of state, local, and federal officials who could consistently monitor water supply and moisture, and help inform response actions to reduce drought impacts. The Drought Advisory Committee consolidates water supply and moisture information on a monthly basis for state and local agency officials with responsibility to manage natural resources and support constituents most likely affected by drought. It also does a monthly assessment of forecasts (precipitation/temperature), mountain snowpack, streamflow, soil moisture, reservoir status, and agricultural and livestock production. The committee is charged with developing a state drought plan, and provides planning support and information sharing with watershed groups and county drought committees through its website and staff.
- **The Montana Climate Office** was designated in 2006 as the official steward of climate information and services for the state of Montana, maintaining climate station data for the state, and assisting stakeholders in interpreting climate information or adapting climate products to their needs. Some of their current datasets include:
  - -- Gridded precipitation
  - -- Gridded temperature (min, mean, max)
  - -- Normalized Difference Vegetation Index (NDVI)
  - -- Enhanced Vegetation Index (EVI)
  - -- Evapotranspiration (ET)
  - -- Potential evapotranspiration (PET)
  - -- Drought Severity Index (DSI)
  - -- Source datasets for all of the above and additional Montana Climate
  - -- Office resources

From the pre-workshop survey

What are you hoping to learn from the workshop on Building Drought Early Warning Capacity in Montana?

- Rather than learning short-term annual warnings about drought, I hope there is some discussion of long-term measures to adjust to reduced water supplies.
- Hoping to bring back some tools to better assist my field office in drought years. And to help make our watersheds even more drought resilient.
- Useful information, in lay people's terms, on why it is important, how to convey information and solutions to share with my stakeholders
- A template to begin working on a drought plan
- New tools / strategies / funding sources for drought resilience / preparedness
- I was not in a water leadership position during any previous severe droughts. I am hoping to learn effective tools for communicating and decision-making, along with any other information I can!
- I'm hoping to get a better understanding of the drought related work that others are doing around southwest Montana.
- How can global atmospheric and oceanic circulation patterns help create climate outlooks in southwest Montana? Are there new/emerging monitoring tools that we should know about? How can we use a suite of early warning tools/info to give the community a more complete picture of how drought is affecting our area?

From the pre-workshop survey

What critical impacts could be reduced?

- Efficient shared water use could mitigate some impacts
- Impacts to riparian areas as well as uplands from livestock grazing
- Agriculture, fisheries, and public water interests could mitigate some impacts with early planning.
- We might be able to avoid total dewatering of the stream. Just to maintain survival flows for the resource during the critical years would be a success. Increasing the resiliency of agricultural producers would be another way to reduce impacts.
- Impacts to those reliant on crop production could be reduced as they could plan more drought tolerant crops for the affected growing seasons. Impacts in the wildland urban interface could potentially be reduced as resources could be directed more heavily to education/prevention of those effects. Municipal water suppliers could be better prepared and enact measures to further conserve water. Dam managers could also be prepared and maximize storage.

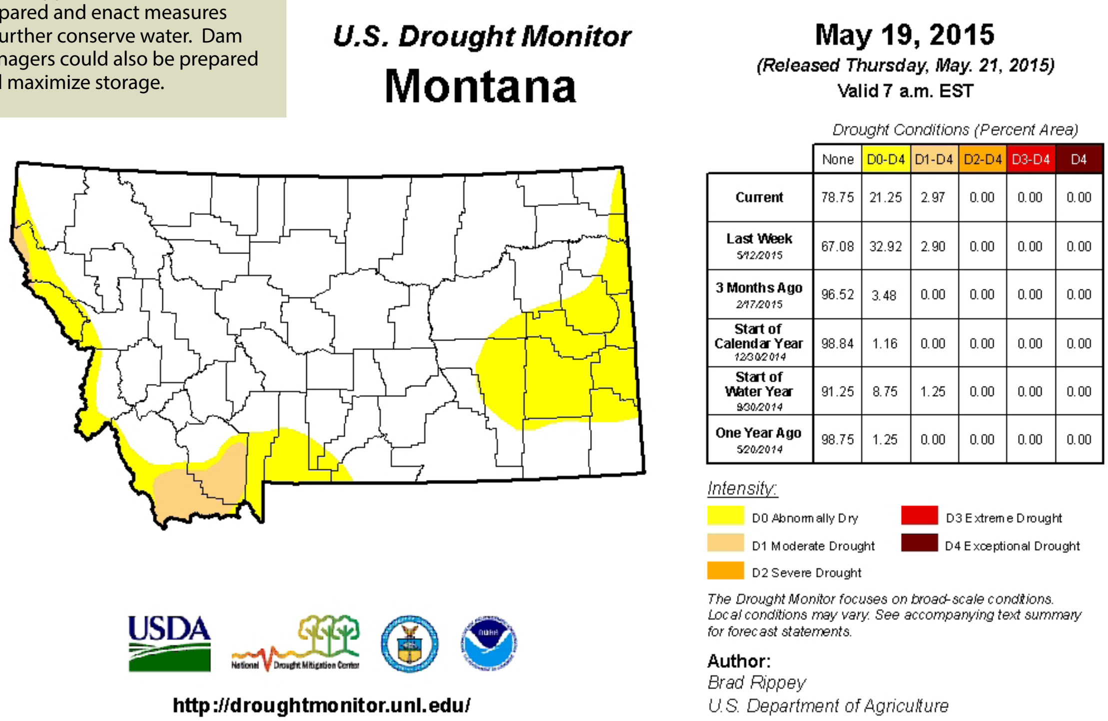
DROUGHT INDICES

The US Drought Monitor

Given the typically slow onset of drought and its complexities, it lends itself quite well to using indicators and indices to predict and monitor its progression. One of the primary composite indicators used to monitor drought in the U.S. is the U.S. Drought Monitor (USDM) which has been produced weekly since 1999.

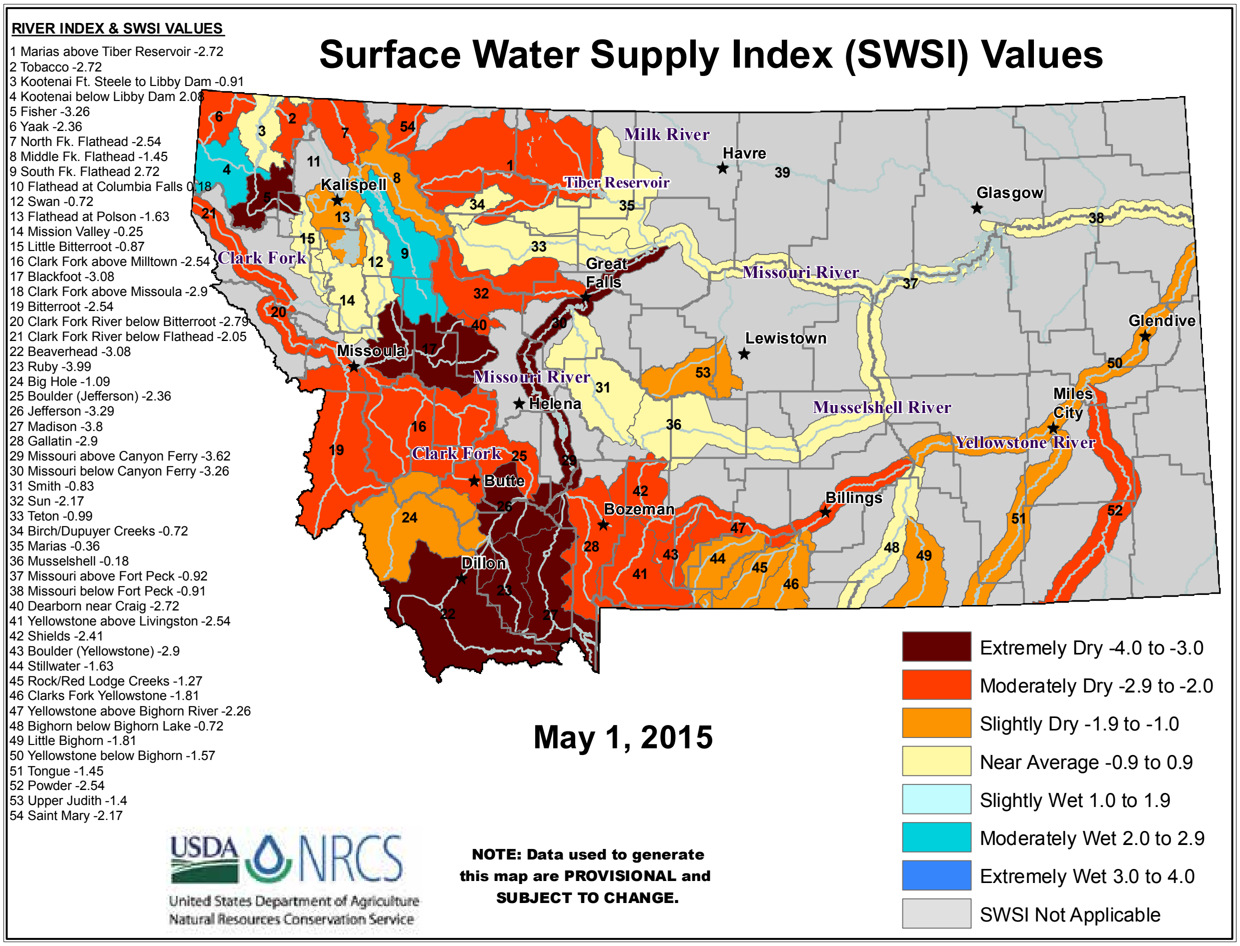
There are four basic drought perspectives: 1) meteorological; 2) agricultural; 3) hydrological; and 4) socioeconomic, and there are indices and indicators associated with each. No one index or indicator adequately describes all aspects and types of drought. In developing its weekly map, the USDM integrates multiple data sources and derivative products from local to national scales, and incorporates feedback and input from an expert user group of more than 350 people from across the U.S.

For agricultural producers, the USDM is used as a trigger to initiate and/or terminate several programs in USDA's Farm Service Agency (FSA). FSA uses the USDM to identify areas eligible for emergency haying and/or grazing support through the Conservation Reserve Program, as well as grazing losses due to drought under the Livestock Forage Disaster Program (LFP). The Internal Revenue Service is also using the USDM for tax deferrals for livestock producers who involuntarily sell livestock due to drought conditions. Montana participates in the development of the USDM through a coordinated weekly process lead by the National Weather Service's (NWS's) Great Falls Weather Forecast Office.



	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	78.75	21.25	2.97	0.00	0.00	0.00
Last Week 5/12/2015	67.08	32.92	2.90	0.00	0.00	0.00
3 Months Ago 2/17/2015	96.52	3.48	0.00	0.00	0.00	0.00
Start of Calendar Year 12/30/2014	98.84	1.16	0.00	0.00	0.00	0.00
Start of Water Year 9/30/2014	91.25	8.75	1.25	0.00	0.00	0.00
One Year Ago 5/20/2014	98.75	1.25	0.00	0.00	0.00	0.00

The status of drought in Montana as depicted by the U.S. Drought Monitor (USDM) for the week of May 19, 2015. The USDM is updated every Thursday morning. The date of the map reflects the cut-off date (Tuesday preceding the update) for new information to influence that week's update.



Montana's Drought Advisory Committee also uses several other indices. These include the Surface Water Supply Index, pictured above, and the Montana Water Supply and Moisture Status by County (pictured on page 4).

As the name implies, the Surface Water Supply Index (SWSI), pictured above, is an indicator focused on the status surface water supply. The index takes into account snow melt/snowpack, mountain precipitation, streamflow, reservoir storage, and soil moisture conditions. SWSI maps and reports are available for each month from January through October beginning in 1992 on the Montana State Library website: http://mslapps.mt.gov/Geographic_Information/Maps/watersupply/SurfaceWaterSupplyIndex/Default.aspx

ASSESSING IMPACTS AND VULNERABILITIES

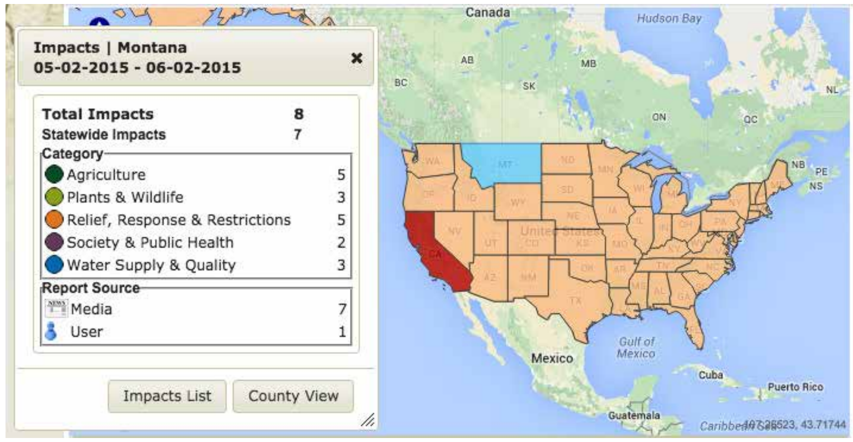
Having an early indication that drought will develop or intensify is critical to employing strategies that can mitigate and reduce the impacts. A simple definition of drought could be "insufficient water to meet demand." Demand can be based on instream flows for a healthy functioning ecosystem or on institutional and economic systems linked to human health and welfare. When there is not enough water or moisture to meet demand, impacts begin to emerge. Understanding demand and impacts is critical for systems designed to provide early warning of drought.

During the meeting, the NDMC Director Michael Hayes stated, "You cannot manage what is not monitored." To manage drought you have to monitor impacts and understand vulnerabilities or the consequences of those impacts.

From the pre-workshop survey

In your watershed, do you think vulnerability to droughts has been increasing, decreasing, or remaining the same and why?

- Increasing. Because the land resources are experiencing a cumulative effect from past drought years. For instance, native bunch grasses are more susceptible to drought because due to previous drought years their vigor is low, with each additional drought year the plant begins to die off.
- In the Dillon BLM Field Office I think vulnerability to drought has been decreasing due to good land health management, which is increasing drought resiliency.
- Decreasing due to the development of our Drought Management Plan, but I'm nervous about the upcoming water year after this relatively dry winter.
- I think vulnerability to droughts is increasing on public lands because the agencies have an inability to act in a timely manner; on private lands because of an inability to see the need for adaptability planning and prevention. We are fortunate to have active, effective voluntary drought management plans that have proven to work well, but I see that as a Band-Aid for temporary conditions, not long term planning for the future.
- Increasing vulnerability. More people, more water hungry crops, chasing greater yields and larger cattle, all require more water. Continuing decline in soil organic matter leading to less water holding capacity. Increase in irrigation efficiency and well drilling reducing ground water supplies with no understanding of recharge rate/dynamics.
- Vulnerability decreasing due to improved watershed coordination.
- In the Gallatin Valley, I think our vulnerability to drought has been increasing. The population is expected to triple by the end of the century, and this will create a tension between municipal and agricultural water users. Drought will only compound this issue.



The Drought Impact Reporter can be displayed across a variety of temporal and spatial scales and by sector category. Users can also specify impacts by reporting source.

Drought Impact Reporter

The NDMC launched the Drought Impact Reporter (DIR): http://droughtreporter.unl.edu/ in 2005 as the nation's first comprehensive database of drought impacts. The DIR is a web-based mapping tool designed to compile and display impact information from the media, government agencies, and the public across the U.S. in near real-time. Each of these sources provides different types of information at different spatial and temporal scales. One of the unique aspects of the DIR is that private citizens can submit drought impacts: http://public.droughtreporter.unl.edu/submitreport/

There is also a Drought Impacts RSS feed which displays impacts as they are posted: http://moderator.droughtreporter.unl.edu/rssfeed/

Just knowing the impacts, however, is usually not sufficient for decision makers. Putting those impacts in the context of vulnerabilities and risks allows a decision-making body to determine the significance of a non-response. Two case studies were presented at the meeting that described ways vulnerability assessments have been used. The first was the Hualapai Tribe, which used the Bureau of Reclamation's Drought Program established after the Reclamation States Emergency Drought Relief Act of 1991 (PL 102-250) to conduct a vulnerability assessment of their water supplies, livestock production, wildlife and tourism, and timber. The Hualapai then used the vulnerability analysis to inform their monitoring, response, and mitigation strategies. This was then tested with the NDMC in a drought scenario exercise.

The second case study described Colorado's drought plan and the vulnerability assessment they conducted as part of their planning processes. The assessment focused on six key sectors experiencing the most significant impacts across the state during drought events: recreation, municipal and industry, socioeconomic, environment, energy, and agriculture. Using the NDMC's Drought Impact Reporter, Colorado collected drought impacts by sector and by county. They then created statewide maps based on the data to show where vulnerabilities developed. As Montana continues to work with local authorities on drought planning, it is possible that these vulnerabilities could be incorporated into local plans.

Drought Risk Atlas

NDMC's Drought Risk Atlas (DRA) helps answer the question of how a current drought compares to a previous event. The DRA allows an individual to locate a station closest to their area of interest as well as a cluster of stations with consistent precipitation attributes and see the drought history. It puts an ongoing drought into context with an area's drought history, thereby helping the user visualize and assess risk related to drought.

DROUGHT PLANNING RESOURCES

[*The following section on drought plan features was adapted from the discussion at the meeting and NDMC's website: http://drought.unl.edu/Planning/WhatisDroughtPlanning.aspx*]

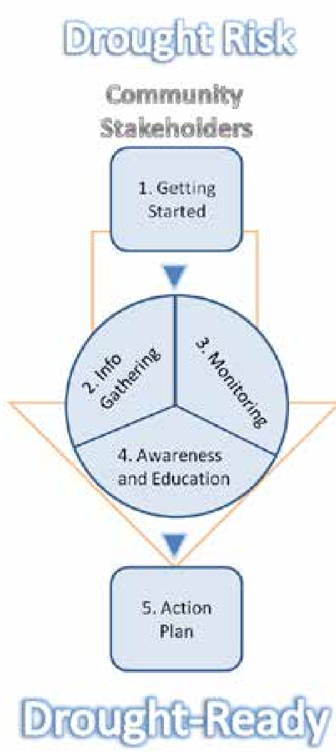
The second part of the meeting focused on steps for creating and implementing a drought plan. The NDMC maintains a searchable database (http://drought.unl.edu/droughtmanagement/Home.aspx) that includes links to drought plans and mitigation actions from states, tribes, cities and municipalities.

A first step in any drought-planning effort is to assemble a team of relevant decision makers and stakeholders. Key questions for the team are:

- ✦ "How will drought affect us?" Looking at past drought impacts helps people understand their vulnerability to drought.
- ✦ "How will we recognize the next drought in the early stages?" Understanding what data are available and collecting more, if necessary, are key.
- ✦ "How can we protect ourselves from the next drought?" The answer to this will vary depending on the enterprise.

After researching impacts, monitoring, and management options, the team can describe how the organization will recognize and respond to drought. In many cases it may be appropriate to identify triggers which would phase in response actions according to the severity of drought.

The team should also consider what the organization can do to reduce long-term vulnerability to drought. For farmers, this could mean management practices that retain water in soil and reduce the need for irrigation. For municipalities, it could be incentivizing more efficient plumbing fixtures, fixing leaks in old pipes or identifying new water supplies. For the federal government, it could be recognizing the interconnections between food, water, and energy, and revamping policy accordingly.



The schematic at left shows the Drought-Ready Communities framework for improving drought preparedness. The process is divided into five areas that were tested in three communities: Nebraska City, NE; Decatur, IL; and Norman, OK.

From the pre-workshop survey

How could you or others in your watershed measure a reduction in impacts?

- ✦ Economic assessment.
- ✦ Quantify surface water, fishery trends, and agricultural production trends.
- ✦ Continue to monitor our resources.
- ✦ Soil moisture content monitoring, water monitoring.
- ✦ Reduced water use.
- ✦ Biomass production/retention, low flow levels in native streams.
- ✦ Surveys, community meetings.
- ✦ Instream flows and crop yields.
- ✦ Measuring streamflow in critical reaches would be one way. Tracking cattle and crop production would be another.
- ✦ Impacts could be measured in an economic sense by comparing yield from drought years to non-drought years.
- ✦ Statistics related to fisheries, habitat, and agriculture, ie, fish number and size, stream temperatures, soil moisture, irrigation allotments.
- ✦ Health studies of livestock and crops in the area in times of drought.
- ✦ Landowner surveys of drought impacts, communication between state agencies (e.g. USFS, NRCS, FWP, CDs), comparing to similar watersheds (e.g. crop production yields, well monitoring), photos to monitor land changes.

From the pre-workshop survey

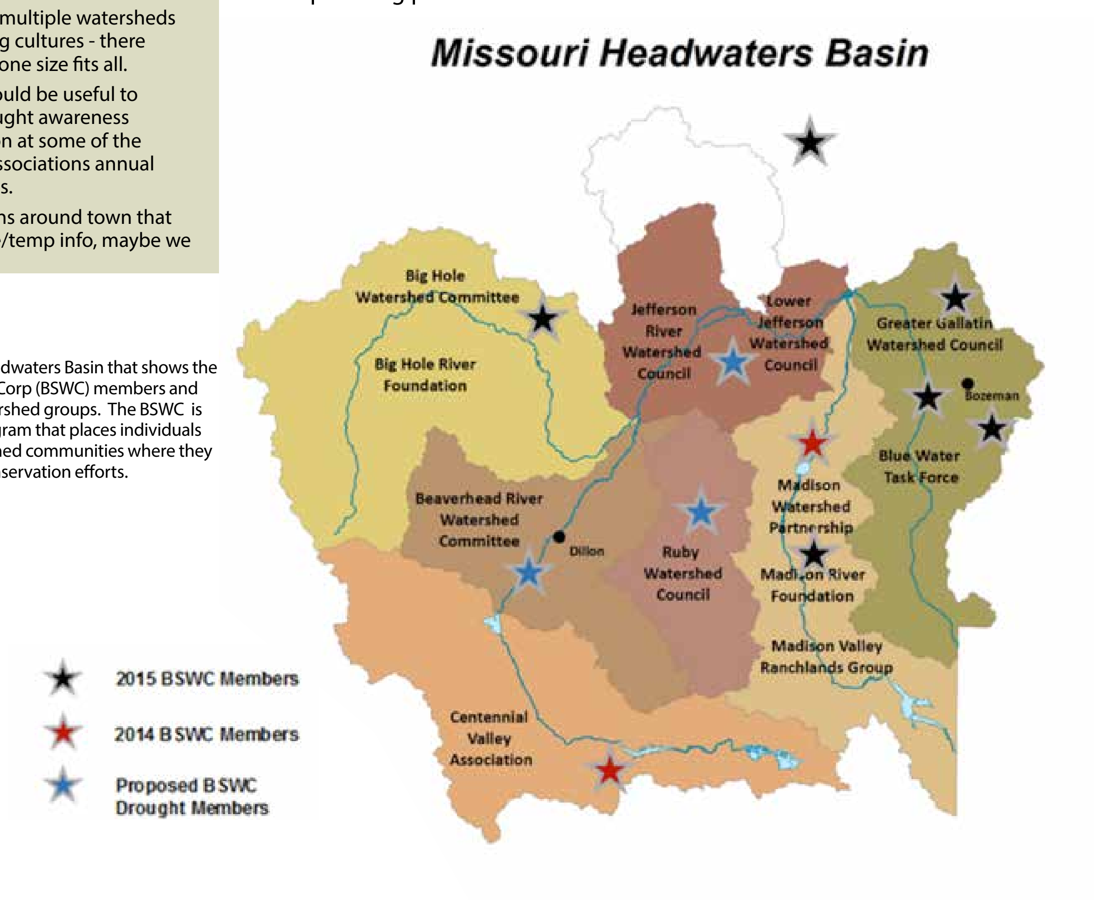
Do you have suggestions regarding ways to improve drought awareness and/or information delivery in the watershed you represent?

- Public awareness is relatively high about the basic effects of drought, but relatively low on measures to adjust to drought.
- Inventory all tools, determine needs, deliver
- Work closely with conservation districts to include most up-to-date resources in their regular customer correspondence/ outreach.
- drought.mt.gov is a good site for the state-wide/ large basin level. At the watershed level, there needs to be key people who understand and have access to the information, and who can get the word out to the local users.
- Locally relevant data will get shared more widely.
- I represent multiple watersheds with varying cultures - there really is no one size fits all.
- I think it would be useful to have a drought awareness presentation at some of the Ag Trade Associations annual conventions.
- On LED signs around town that depict time/temp info, maybe we

Some management options could be implemented in the short term, such as encouraging homeowners to use xeriscaping rather than lawns in dry regions. Other options such as upgrading infrastructure or implementing smart growth development practices can take years. Fortunately, many measures that reduce long-term drought risk also contribute to community health in other ways, so implementing drought risk reduction measures can coincide with other efforts to implement a healthier, more sustainable food and agriculture system, and prepare for other natural hazards.

BIG SKY WATERSHED CORPS MEMBER REPORT OUT AND COMMON THEMES

The Big Sky Watershed Corps (BSWC) members, watershed coordinators, and other participants from the Upper Missouri watersheds (see map below) were asked to use the drought planning methodology presented by the NDMC to consider how those principles might apply to their respective watersheds. This could be either integrated into existing planning efforts, such as a Watershed Restoration Plan, or it could be used to initiate a new planning process. The following section provides a short description of each watershed, opportunities and existing partnerships, and next steps proposed by the BSWC members in their planning processes.



Upper Missouri Headwaters Basin that shows the Big Sky Watershed Corp (BSWC) members and their affiliated watershed groups. The BSWC is an Americorps program that places individuals in Montana watershed communities where they undertake local conservation efforts.

Summary of the unique geography, activities and challenges, and key economic considerations for the BSWC watersheds.

WATERSHED	GEOGRAPHY	ACTIVITIES & CHALLENGES	ECONOMY
Beaverhead River[1]	**Drainage area:** 3,620 sq. mi. (includes Red Rock.) **Median annual volume of water produced:** 592,000 a.ff **Length:** ~ 69 miles	Land use change and management; persistent drought over the past decade	Mostly focused agriculture and recreation interests. ~55% of the land area is federally or state owned
Ruby River[2]	**Drainage area:** 965 sq. mi. **Median annual volume of water produced:** 216,000 a.f. **Length:** ~ 76 miles. Origin in Gravelly and Snowcrest mtns., flowing to confluence with the Beaverhead near Twin Bridges, MT.	Dewatering of tributaries, irrigation conveyance; competing needs between agriculture and fishing sectors. Previous droughts caused wildfire, reduced stream flows, and reduced water quality and soil health	Livestock production primarily on public land in the upper watershed for summer pasture; recreational fishing, with several lodges and two fly rod manufacturers in Twin Bridges. Approximately 1200 residents.
Big Hole River[3,4]	**Drainage area:** 2,500 sq. mi. **Median annual volume of water produced:** 817,000 a.f. **Length:** ~ 150 miles.	In 1997 the BHWC developed Big Hole Drought Management Plan to mitigate the effects of low water quality for fisheries (particularly the Arctic grayling) through a voluntary effort among agricultural operations, municipalities, businesses, conservation groups, anglers, and affected government agencies. The plan has been updated almost every year since, most recently in 2015.	Cattle production; 70% public ownership and 30% private; fishing (blue ribbon trout stream). Fewer than 2,000 year-round residents
Jefferson River[5]	**For portion from confluence of Beaverhead and Jefferson to Missouri at Three Forks:** **Drainage area:** 2,445 sq. mi. **Median annual volume of water produced:** 120,000 a.f. **Length:** ~ 83 miles.	Maintaining flow to support the ecosystem, and the fishery in particular; changes in land and water uses; aquatic invasive species; coordinating information among the tributaries	More than 57% of the land is private; the rest administered by USFS, BLM, and DNRC Trust lands
Madison River[6]	**Drainage area:** 2,510 sq. mi. **Median annual volume of water produced:** 1,310,000 a.f. **Length:** ~ 183 miles. Origin in Yellowstone N.P., at confluence of Firehole, Gibbon Rivers. Lee Metcalf Wilderness area, the Madison range, and the Big Sky resort communities surround the Madison Valley.	Development; changing land and water use; chronic dewatering; nutrient overload; irrigation conveyance and infrastructure; ice jams; high percentage of absentee landowners	Agriculture; tourism, abundant wildlife and trout fishing.
Gallatin River[7,8]	**Drainage area:** 1,800 sq. mi. **Median annual volume of water produced:** 946,000 a.f. **Length:** ~ 120 miles. Origin in Yellowstone N.P., flowing through Gallatin National Forest, Gallatin Canyon. Passes Big Sky Ski Resort and city of Bozeman. It has 23 major water bodies and 394 miles of streams.	Upper Gallatin: Resort development and water management; no existing drought plan Lower Gallatin: City of Bozeman is working on a drought plan for its municipal water supply; the West Gallatin agricultural users have established a sub-watershed plan to ensure the West Gallatin is not dewatered	Tourism, fly fishing destination (portions of the upper river have been designated as a blue ribbon trout streams); agriculture; unprecedented growth in Bozeman and the region

References:
1. Beaverhead Watershed Restoration Plan: http://www.beaverheadwatershed.org/beaverhead-tmdl-and-watershed-restoration-plan/
2. Ruby Valley Conservation District and Ruby Watershed Council: http://www.rvcd.org/rwc/about-the-rwc
3. http://bhwc.org/
4. http://www.fws.gov/mountain-prairie/pfw/montana/mt3c.htm
5. Jefferson River Watershed Council: http://www.jeffersonriverwc.org/index.html
6. Madison Watershed Assessment Report: http://www.blm.gov/pgdata/etc/medialib/blm/mt/field_offices/dillon/madison.Par.4414.File.dat/report.pdf
7. Upper Gallatin Watershed Restoration Plan: http://www.bluewatertaskforce.org/documents/WFWRP070612_256.pdf
8. Lower Gallatin Watershed Restoration Plan: http://www.gallatin.mt.gov/Public_Documents/GallatinCoMT_WQDReports/Lower_Gallatin_WRP_122214.pdf

Beaverhead Watershed

The watershed boasts significant experience with drought planning and well-established partnerships already, but there were several data and information gaps noted. The need for improvements in snowpack monitoring was noted as critical given the relatively small size of the watershed and need for fairly fine resolution of the data. The possibility of a new SNOTEL site in the Pioneer Mountains was highlighted. Better understanding of both gaining and losing stream reaches was also noted as critical. Improved accessibility of data and information to the public was another area noted as being important, as well as engaging the public and improving local observations through citizen scientist efforts like the Community and Collaborative Rain, Hail, and Snow (CoCoRaHS:) http://www.cocorahs.org/.

Actions: The BSWC member proposed producing a drought memories video, which would be an opportunity to engage residents, record individual experiences and document memories. This project could potentially partner with the historical society. Other ideas expressed were the potential assessment of different approaches to offset grazing through practices such as grass banking; engaging the Beaverhead County Drought Task Force and the Clark Canyon Joint Board to improve coordination; and enhancing access to data such as precipitation, snowpack, streamflows, soil moisture, and seasonal forecast. Finally, the BSWC member would consider assessing ways to improve Beaverhead County stakeholders' understanding of where drought-related data and information come from, and how they are used for decision-making at the state and federal level.

THE BEAVERHEAD has seen persistent drought over the past decade. Photo: http://www.beaverheadwatershed.org/wp-content/uploads/2014/06/IMG_21741-e1403042289380.jpg

THE RUBY RIVER is home to several fly-fishing ldges and two rod manufacturers. Photo: http://cdn.bozemannet.com/images/content/22706_BpIrx_Ruby_River_Fishing_md.jpg

Ruby River Watershed

Challenges noted were the historic mining activities in the area, changing land and water use, chronic dewatering of tributaries, irrigation conveyance, and competing needs between the agriculture and fishing sectors. There is considerable information from the water users association (mapping data; plans; reports), but gaps remain, such as soil moisture and groundwater monitoring; improving understanding of ground-water-surface-water interactions; plant monitoring to evaluate range health; and precipitation and snowpack conditions. Impacts from previous droughts have included wildfire, reduced stream flows, reduced water quality, and soil health.

Actions: The Ruby Watershed BSWC member noted several potential next steps for improved early warning and drought resilience. These included improving public awareness and education, continuing the weekly column in the Madisonian newspaper, considering seasonal forecasting (fall timeframe) to initiate stakeholder discussions and ways to improve proactive decision-making, inviting a reporter from the Madisonian to write drought-related articles during key times of year, conducting mini-workshops to share information with the public and consolidating information into accessible summaries or handouts. The group also discussed conducting a pilot with a high profile local producer and identifying thresholds and trigger dates (e.g. pre-irrigation season; irrigation season; hunting season).

THE BIG HOLE'S STAKEHOLDERS together created a Drought Management Plan to mitigate the effects of low water quality for fisheries (particularly the Arctic grayling) through voluntary cooperative efforts. Photo: http://www.nps.gov/biho/learn/nature/images/BIHO_River_and_BIHO_scene_20090624.JPG

Big Hole Watershed

During the discussion the BSWC member for the Big Hole noted that despite the success of the watershed in collaborating around the Arctic grayling and other issues, there was still a need for education and outreach on being proactive with drought responses prior to the onset of an event. Expanding the Big Hole Drought Plan beyond artic grayling was also noted as a potential need, as well as improving participation from groups and individuals at both the lower and upper Big Hole River watershed. The Big Hole Watershed is unique in that it formed the first watershed group: the Big Hole Watershed Committee (BHWC). The BHWC was formed in 1995 as a response to persistent drought and the potential listing of the Arctic grayling.

Actions: One of the potential ways to improve education and common understanding would be to host a role-playing workshop where stakeholders in the watershed could experience different perspectives by exchanging roles with another sector or group. If conducted, the workshop would ideally work through a set of drought scenarios where difficult decisions and trade-offs regarding water use would be made. Another opportunity discussed was to consider ways to improve drought education, such as conducting talks and presentations at the Big Hole Watershed Committee monthly meetings. This process would also allow assessing community drought perceptions and information needs. Finally, the BSWC member would consider ways to leverage stream restoration projects, such as methods for improving natural water storage, and the rational for expanding the BHWC drought plan beyond the artic grayling.

Jefferson River Watershed

The Jefferson River Watershed Council (JRWC) was created in 1999 by irrigators with the idea to ensure ample water for irrigation while at the same time ensuring enough flows remain to maintain a healthy river ecosystem. In 2010 the JRWC created a Water Restoration Plan primarily to reduce the transport of sediment into the river. The plan also prioritizes issues such as maintenance of base flows, riparian restoration, noxious weed control, flood plain planning, fisheries enhancement, irrigation water management, prescribed grazing systems, protection and maintenance of the local agricultural economy, the need to periodically evaluate the drought management plan, and

THE JEFFERSON RIVER'S DRAINAGE includes more than 800 square miles. Photo: http://water.weather.gov/ahps2/images/hydrograph_photos/twim8/dscn2863.jpg

groundwater characterization and management. The JRWC is also working with USGS to develop modeling to understand the watershed and habitat response to climate variability and change. Important partnerships in the watershed include Montana Fish Wildlife and Parks, Trout Unlimited, Jefferson County Commissioners, Lower Jefferson Watershed Council, and the Montana Bureau of Mines and Geology groundwater assessment.

Actions: Opportunities discussed that could be pursued included assessing whether the drought management plan developed 15 years ago, and updated in 2008, requires another revision. The river is over-allocated and the original plan was created to stop the river from being dewatered. The DNRC and FWP led the process focused on making moderate improvements within existing water rights. These efforts showed progress and that a new process would need to follow a similar course and engage influential stakeholders that could help lead the dialogue and represent various interest groups (e.g., agriculture and Trout Unlimited). The plan does not include the lower Jefferson River, which would need to be assessed in a new revision. The current drought plan does consider coordination with the Big Hole River Drought Plan but it is not clear how information from the Ruby and the Beaverhead Rivers could be used.

Madison River Watershed

The Madison Valley has a large number of agricultural producers as well as abundant wildlife. Trout fishing is extremely popular and a significant contributor to the local economy. Development, changing land and water use, chronic dewatering, irrigation conveyance and infrastructure, ice jams, and a high percentage of absentee landowners are just a few of the challenges in the watershed. There are several key groups and partnerships in the Madison Watershed, including the Madison Conservation District, the Madison River Foundation, Madison Valley Ranchlands groups, Wildlife Conservation Society, The Montana Wetlands Council, Greater Yellowstone Coalition, and Trout Unlimited.

Actions: The Madison Watershed Restoration Plan is still being developed, however the watershed has been extremely active over the years with stream monitoring teams and gathering monthly data at multiple sites. The discussion of next steps to improve drought resilience and early warning focused mostly on integrating these goals with existing efforts like Montana DEQ's goals and the effort to develop a watershed restoration plan for the Madison. For example, dewatering and nutrient overload are big issues and will be exacerbated by drought. How can these things be addressed, leveraging all available programs and mandates, and funding? Other ideas discussed were ways to communicate the economic value associated with fishing, and building better relationships in the watershed by hosting a role-playing workshop to help everyone better understand different perspectives.

Gallatin Watershed

There are many groups and existing partnerships in the watershed actively working towards solving several natural resource and water challenges. There are also several BSWC members working in the Bozeman and Big Sky area. Some of the key groups include the Greater Gallatin Watershed Council, Blue Water Task Force, City of Bozeman and Gallatin Local Water Quality Districts, One Montana, Gallatin Conservation District, Jack Creek Preserve Education Center, Gallatin Valley Land Trust, Trout Unlimited Montana Water Project, Montana Aquatic Resources Services, and the Montana State University Water Center and Researchers. Given the size and the diverse features of the Gallatin Watershed the discussion was divided into the Upper and Lower Gallatin Watershed.

Upper Gallatin Actions: There is little agriculture in the upper watershed and the primary issue has been related to resort development and water management. While there have been a number of efforts focused on water quality, there has not been as much attention to the management of water quantity. There is no existing drought plan for this part of the watershed.

Key partners to engage in the water management issue would be the board for the Blue Water Task Force, Yellowstone National Park, USFS, Big Sky Ski Resort, golf courses, and state agencies. A first approach could be to focus on water conservation by improving outreach and educational activities. This could include identifying incentives to engage people, such as holding a competition between various areas to support conservation using EPA's H2Otel Challenge (http://epa.gov/watersense/commercial/challenge.html). A potential local resource and model for water efficiency efforts could be the City of Bozeman and its efforts to roll out the hotel challenge in the Fall of 2015.

Lower Gallatin Actions: The Lower Gallatin covers approximately 997 square miles and includes both urban and agricultural stakeholders. The Lower Gallatin sub-watershed starts at the headwaters of Hyalite Creek and ends at the confluence of the Gallatin, Madison, and Jefferson rivers. Potential activities discussed at the meeting include: the City of Bozeman is working on a drought plan for the city's municipal water supply; the West Gallatin agricultural users have established a sub-watershed plan to ensure the West Gallatin is not dewatered; and there was a suggestion to continue working on sub-watershed drought plans for other parts of the Lower Gallatin, such as the East Gallatin. Another potential idea to consider was to use the Lower Gallatin Restoration Plan and 319 funding to get irrigators involved in drought-related work. Public outreach and participation was another area that needs attention. For example, establishing a volunteer monitoring network (CoCoRaHS) was one way to improve public participation in monitoring for drought. Another approach was to improve the way drought is framed by describing it in conversational terms (e.g., drinking water; fire). For the Lower Gallatin it was noted that a successful public outreach campaign would need to resonate with both urban and rural residents.

THE GALLATIN originates in Yellowstone National Park and flows north to Bozeman, requiring drought planning which includes wilderness, rural and urban interests. Photo: http://commons.wikimedia.org/wiki/Category:Gallatin_River#/media/File:GallatinRiver1997.jpg

16 MISSOURI HEADWATERS BASIN WORKSHOP

Workshop participants form the Missouri headwaters met for two days in Bozeman, Montana in March 2015.

POST-WORKSHOP SURVEY

Following the workshop, the participants received a survey asking their opinions of the workshop, and what were the most important things they learned as a result of the meeting. Approximately 60% filled out the survey. When asked about the most important ideas, resources, or information that they took away from the workshop, participants mentioned learning about the large amount of useful information and resources that exists for drought monitoring and management, learning about processes for drought planning, learning who they can work with as partners, and learning more about the other individual watershed councils and issues they are facing locally.

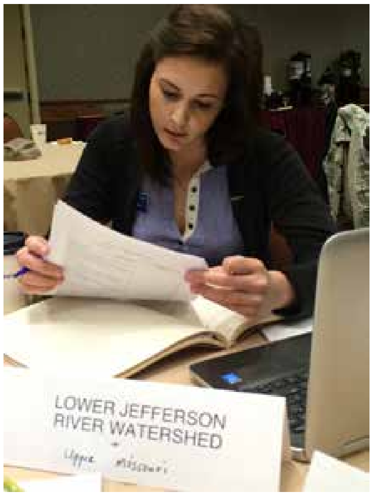
Some sample comments:

- ✦ "There is a large amount of useful information, but very little in place at the local level for real time stream flow data & coordination between the stakeholders. In addition to more support by the state for stream gages & coordination between resource agencies and other stakeholders there needs to be more time spent on identifying and implementing Best Management Practices which could be implemented to conserve or reduce water use. Water rights & money will run over any plan developed by resource groups not coordinating completely with water right holders. Most of the watershed groups in place have young inexperienced staff working on very small budgets. Not a recipe for a successful implementation of a drought management plan implementation when a major drought hits."

- ✦ "Through this workshop, I realized how important it is for our community to develop a drought/water plan. I really enjoyed brainstorming the first steps of developing a plan on the second day. I also enjoyed networking with colleagues and others involved in drought planning."
- ✦ "Starting to think about drought as a human and economic problem, not just a climate/environment problem."
- ✦ "Interesting to see both similarities and differences across the watersheds in the issues they are facing and things they will need to deal with in their drought plans."

About 60% of the respondents said that, after the workshop, they were able to identify at least one course of action that they could take to minimize future drought risk in their watersheds, including stream restoration and starting a drought plan. When asked about steps that they hoped to take in their watershed over the next six months, to minimize future drought risk, participants listed the following:

- ✦ "Complete our watershed restoration plan to include potential projects that would result in natural water storage."
- ✦ "In the next six months, I hope we can start a conversation about drought among residents and other organizations in the watershed through education programs."
- ✦ "Improve data resources and accessibility. Possibly write a local drought plan."



Studying planning materials for the Lower Jefferson.

- "The JRWC drought management coordinator working with the FW&P's will increase their initiative to work closer with the watersheds in the Ruby, Beaverhead and the Big Hole."
- "Facilitate meetings on beaver mimicry structures as a tool to level the hydrograph and raise the water table."
- "We just had a planning meeting in one of my watersheds and discussed projected water supply conditions for the upcoming season. We also discussed with the major water users how we could better coordinate diversions and storage releases to meet needs and maintain minimum flows in the river."
- "Over the next six months, I would like to have discussions with community leaders about developing a plan, finding a facilitator for this process, and a funding source."
- "Education is the biggest arena I can effect change with."
- "Discuss with others to see dollar values on ranching and fishing in Madison."
- "Have already brought the subject of drought planning up as agenda item to our local landowners group. Will likely have a meeting in the community on this subject in next six months."
- "Actual implementation of water management projects in response to drought triggers."

When asked about more training, two-thirds of respondents said they would like to learn more about other existing drought plans. About half said they would like to learn more about tools and monitoring and forecast products such as snowpack, precipitation, temperature, streamflow and streamflow forecasts, fire risk assessment, seasonal climate prediction, etc.; vulnerability assessment; and communication techniques. Their preferred means of receiving this information were through webinars, short videos, and in-person workshops.

SUMMARY AND CONCLUSION

The meeting brought the watershed communities together to learn more about drought planning tools; NDMC and NIDIS; exchange information across state and federal agencies working in the basin (e.g. MT DEQ, EPA, NRCS, BLM, USFWS, USFS); and to learn more about the challenges, opportunities and existing work and activities occurring across the Upper Missouri Basin. Tools such as NDMC's Drought Risk Atlas and Drought Impact Reporter were demonstrated, while the watershed participants and community stakeholders shared their successes as well as their concerns for dealing with drought. Several themes emerged from the meeting:

1) What could be done in the watersheds recognizing all of the work already underway;

2) How to leverage, integrate and build on existing successful efforts such as watershed restoration plans (WRPs) many of the watersheds have already developed;

3) Developing and enhancing collaboration with active NGO partners, state agencies, universities, and private citizen interests.

Central Activities for the Big Sky Watersheds

- ✦ Develop a Missouri Basin Headwaters Plan: Working through the BSWC members and watershed coordinators, develop a plan that integrates the Upper Missouri River watersheds to foster early warning and proactive planning for drought
- ✦ Watershed groups assess ways to integrate existing water planning concepts into the discussion of drought early warning and overall drought resilience for their watersheds
  - -- For example: Use the process of Watershed Restoration Planning and 319 funding to involve stakeholders (e.g. irrigators) in drought-related planning.
  - -- Assess models and or mechanisms that could support sub-watershed planning efforts like the West Gallatin plan.
- ✦ Conduct drought scenario workshops. These workshops would primarily focus on exchanging perspectives, and assessing triggers, data gaps and coordination needs within as well as among watersheds
- ✦ NDMC, NIDIS, and DNRC with the BSWC members and watershed coordinators continue the dialogue through webinars and in-person meetings to exchange information on drought planning (e.g. NDMC's Managing Drought Risk on the Ranch), improving understanding of season climate forecast, and other topics of interest.•
- ✦ For watersheds with large resorts and rapid urban development, support water conservation efforts like those the City of Bozeman are implementing.

RESOURCES

National Integrated Drought Information System
http://www.drought.gov/drought/

National Drought Mitigation Center
http://drought.unl.edu/

Montana Department of Natural resources and Conservation
http://dnrc.mt.gov/

U.S. Drought Monitor
http://droughtmonitor.unl.edu/Home.aspx

Drought Risk Atlas
http://droughtatlas.unl.edu/

Drought Impact Reporter
http://droughtreporter.unl.edu/

Western Regional Climate Center
http://www.wrcc.dri.edu/

Montana Climate Office
http://www.climate.umt.edu/

Montana's Current Water Supply and Moisture Conditions by County
Montana Surface Water Supply Index
http://drought.mt.gov/default.aspx

USDA Montana State Farm Service Agency
http://www.fsa.usda.gov/FSA/stateoffapp?mystate=mt&area=home&subject=landing&topic=landing

USDA Forest Service Active Fire Maps
http://activefiremaps.fs.fed.us/activefiremaps.php

Greater Gallatin Watershed Council
http://greatergallatin.org/

Blue water Task Force
http://www.bluewatertaskforce.org/

Gallatin Local Water Quality District
http://www.gallatin.mt.gov/Public_documents/gallatincomt_wqdpages/lwqd

One Montana
http://www.onemontana.org/

Gallatin Conservation District
http://www.gallatincd.org/

Jack Creek Preserve Foundation
http://www.jackcreekpreserve.org/

Gallatin Valley Land Trust
http://www.gvlt.org/

Trout Unlimited Western Water Project
http://www.tu.org/tu-programs/western-water

Montana Aquatic Resources Service
http://montanaaquaticresources.org/

Montana Water Center
http://www.montanawatercenter.org/

Madison Conservation District
http://madisoncd.net/

Madison Watershed Partnership
http://madisoncd.net/madison-watershed-partnership/

Madison Stream Team
http://madisoncd.net/category/madison-stream-team/

Madison Valley Ranchlands Group
http://www.madisonvalleyranchlands.org/

Nature Conservancy Montana Chapter
http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/montana/index.htm?intc=nature.tnav.where.list&src=sea.AWP.PR0.CP215.AD151.KW5845.MT1.BU930&nst=0&adpos=1t1&creative=81534812438&device=c&matchtype=b&network=g&gclid=CMCfyPKgvcYCFQ-maQod5uYAqw

Greater Yellowstone Coalition
http://www.greateryellowstone.org/

Madison Farm to Fork
http://www.madisonfarmtofork.com/

Ruby Valley Conservation District
http://www.rvcd.org/

Ruby Habitat Foundation
http://www.rubyhabitat.org/default.php.html

Gravelly Collaborative
http://gravellycollaborative.org/

High Divide Collaborative
http://www.craigheadresearch.org/high-divide1.html

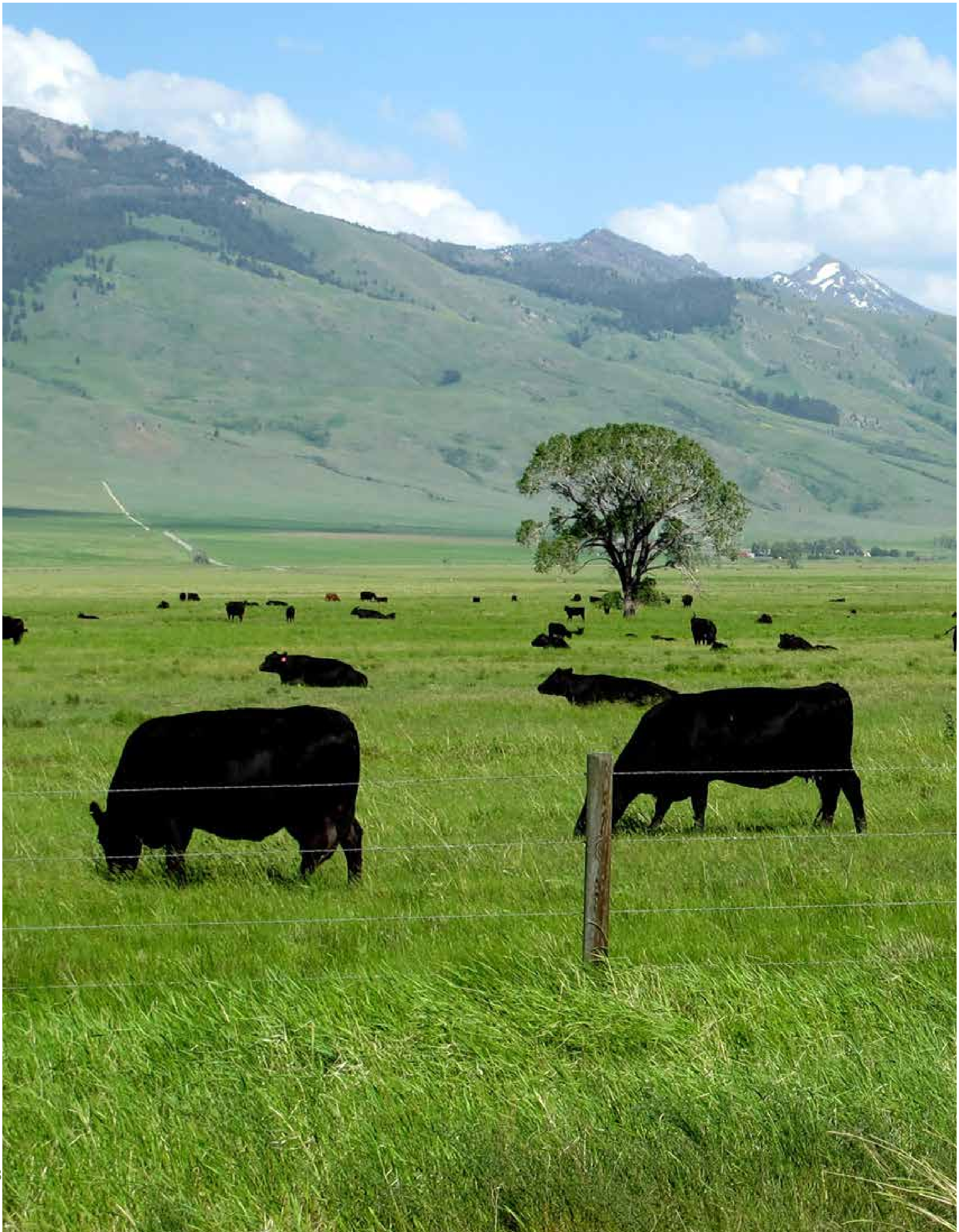
Jefferson River Watershed Council
http://www.jeffersonriverwc.org/

Centennial Valley Association
http://www.centennialvalleyassociation.org/

Beaverhead Watershed Committee
http://www.beaverheadwatershed.org/

Montana Association of Conservation Districts:
http://macdnet.org/

Montana Watershed Coordination Council:
http://www.mtwatersheds.org/



APPENDIX 4

COURSE OUTLINE:
MONTANA DROUGHT RESILIENT COMMUNITIES
Offered through the
Missouri Headwaters Drought Resilience Demonstration Project

Through this course, participants will work with national, state and local experts to develop approaches for drought in their communities. Instructors will cover course materials during monthly two-hour interactive webinars. Homework assigned between the classes will offer opportunities to assemble and review relevant information that will be used in the development of a local drought planning outline. Most importantly, these outlines will identify mitigation and response strategies geared towards building long-term resiliency. Relying on a consistent drought planning template will facilitate development of a regional drought plan for the Upper Missouri Headwaters.

February 23
10 am - noon

Drought Planning and the Missouri Headwaters
Chad McNutt, National Integrated Drought Information System

This class will provide an overview of the drought planning process, describing the benefits of developing a drought plan and outlining the core elements of a plan. Methods for engaging the community in the planning process, identifying key stakeholders, and evaluating linkages to other planning documents will also be discussed.

March 22

Understanding Water, Climate and Drought in the Community
Mark Svoboda, National Drought Mitigation Center

This class will focus on the process for gathering data on drought indicators (e.g., snowpack, streamflow, soil moisture, precipitation) and tools to synthesize the information to understand current and historic local drought conditions.

April 12

Vulnerability Assessment
Dr. Mike Hayes, National Drought Mitigation Center

Identification of drought vulnerabilities is a key step in the drought planning process. During this webinar, participants will learn how to identify vulnerabilities within their watershed.

May 3

Developing Response and Mitigation Plans

This class will discuss approaches to prioritize vulnerabilities and share techniques for developing response and mitigation plans. Local case examples will provide real-world examples about how response plans implemented in Montana have helped communities respond to drought.

May 24

Drought Communication and Outreach in the Community

Successful drought plans are based on having the community invested in the process. This class will discuss methods and tools for communicating the benefits of a drought plan to the community and outline other approaches for engaging the community in future revisions to the plan.

APPENDIX 5

USDA

ht Resilience – Forest to Valley Bottom

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Drought Workshop developed in partnership with:

SNAPP

Wildlife Conservation Society

USDA **United States Department of Agriculture**
Northern Plains Climate Hub

Roundtable on the Crown of the Continent

CMP Crown Managers Partnership

MONTANA DNRC

Alberta Environment and Parks

Workshop conducted as part of the 2017 Crown Managers Partnership Annual Forum

Workshop Objectives:

1) Provide awareness and understanding of the vulnerabilities of drought to key resources.
2) Share and learn from a wide range of agency and private land owners on existing collaboration and management for drought.
3) Learn about and consider adaptation strategies and actions that can be applied to management of private, state, tribal, and federal lands.

Workshop Outcomes:

The workshop will produce a ***summary report*** that outlines:

1) Key drought vulnerabilities important to participants,
2) Adaptation opportunities for specific locations or situations on the landscape (identified by participants), and
3) The challenges, information, collaborations, and organizational capacity needed for successful implementation of the recommended adaption opportunities.

Mangers can use the workshop summary report to assist with considering feasibility, information needs, and partnership opportunities when priorities for actions.

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TUESDAY MARCH 14

SESSION 1: DROUGHT, CLIMATE TRENDS, and ADAPTATIONS

Time	TUESDAY MARCH 14
12:00 PM	Registration Opens
1:00 PM	Welcome **Bill Avey,** *Forest Supervisor, Helena Lewis & Clark*
1:15 PM	Agenda Review, Overview of Workshop Objectives **Lisa Talavia-Spencer**, *Workshop Facilitator*
DROUGHT AND CLIMATE TRENDS (*Moderator: Matt Reeves)*	
1:30 PM	Defining Drought **Chad McNutt**, National Oceanic and Atmospheric Administration's (NOAA) National Integrated Drought Information System – NIDIS
1:50 PM	Eastern Rockies Climate (past and future) trends and meteorological influences to drought **Nick Silverman**, *MT State Climate Office*
2:10 PM	**BREAK**
2:30 PM	Ecological Drought Framework **Aaron Ramirez**, *Science for Nature and People Partnership (SNAPP) Ecological Drought Working Group*
3:00 PM	**REFLECTIONS** Discussion on what information was most important to you? ***Product***: *Generate list of important "climate and drought themes" influencing management.*
3:45 PM	Reporting out
ADAPTATIONS EXAMPLES (*Moderator: Jessica Halofsky)*	
4:15 PM	Adaption workbook for non-forested landscapes – what to do to improve drought resilience? **Hailey Wilmer**, *USDA Northern Plains Climate Hub Fellow*
4:30 PM	Adaption Library - Overview Adaptations Strategies for drought for key resources **Jessica Halofsky**, *University of Washington/Pacific Northwest Research Station*
4:45 PM	Missouri Headwaters Drought Resilience Demonstration Project **Tina Laidlaw**, MT Environmental Protection Agency **Ann Schwend**, MT Dept. of Natural Resources and Conservation - Upper Missouri Basin Water Planner
5:00 PM	Closing remarks and logistics for evening **Lisa Talavia-Spencer**, *Workshop Facilitator*
5:15 PM	**BREAK**
5:45 PM	No host bar
6:15 PM	**Dinner (provided)**
6:45 PM	Evening Speaker - Economic & Social Aspects of Water in Montana **John Tubbs**, *Director - MT Dept. of Natural Resources and Conservation* *(Introduction by Anne Schwend, DNRC)*

WEDNESDAY MARCH 15

SESSION 2: VULNERABILITIES OVERVIEW / MANAGEMENT AND COLLABORATION

Time	WEDNESDAY MARCH 15
8:00 AM	Opening Remarks (**Lisa Talavia-Spencer**, *Facilitator*)
Forest Systems (*Moderator: Amy Gannon*)	
SCIENCE	
8:15 AM	Functional role of forest in hydro system and Fire disturbance - relationship of hydrological process to vegetation structure and function **Bob Keane**, *Rocky Mountain Research Station (US Forest Service*
8:40 AM	Cumulative Impact of Mountain pine beetle as disturbance to forest and forest hydrology **Joel Egan**, State and Private Forestry (US Forest Service)
9:05 AM	Whitebark pine: implications of drought and a high-mountain ecosystem **Michael Murray**, *Ministry of Forests, Lands, and Natural Resources*
9:30 AM	***Q&A***
9:45 AM	**BREAK**
MANAGEMENT AND COLLABORATION	
10:05 AM	Confederated Salish Kootenai Tribes Drought Plan **Mike Durglo (or Rich Janssen or Dale Nelson)**, *Confederated Salish Kootenai Tribes*
10:20 AM	Limber pine – Title - TBA **Dave Hanna**, *The Nature Conservancy* **Amy Gannon,** *MT Dept. of Natural Resources and Conservation*
10:35 AM	***Q&A***
10:50 AM	***BREAK***
Range and Agriculture Systems (*Moderator: Ann Schwend*)	
SCIENCE	
11:05 AM	Impact of drought on rangeland vegetation and agricultural resources **Matt Reeves**, *USDA Northern Plains Climate Hub. Rocky Mountain Research Station (USFS)*
11:20 AM	Soil Health & Water – Title – TBA **Paula Gunderson**, *Natural Resource Conservation Service*
11:35 AM	Hydrology of the Teton River- water management in an over appropriated river basin **Aaron Fiaschetti**, *MT Dept. of Natural Resources and Conservation*
11:50 AM	***Q&A***
12:05 PM	***LUNCH (provided)***
MANAGEMENT AND COLLABORATION	
1:05 PM	Drought Management - Leveraging Existing Water Management Infrastructure in the South Saskatchewan River Basin **Rick Friedl**, *Alberta Environment and Parks*
1:20 PM	Drought and Range Management on Alberta Rangelands **Amanda J Miller**, *Alberta Environment and Parks*
1:35 PM	Green Fields Irrigation District & Water Management on the Sun river **Erling Juel**,
1:50 PM	Agriculture Resource Management Plan **Loren Birdrattler & Gerry Lunak**, *Blackfeet Tribe*
2:05 PM	***Q&A***
2:20 PM	**BREAK**

2:35 PM	**BREAKOUTS: Vulnerabilities and Adaptations – Concurrent sessions for Forest and Rangeland/Agriculture System** **Product:** *Adaptations Options for key vulnerabilities selected by participants*
4:35 PM	Report Out
5:05 PM	End of day debrief (Dinner own your own)

THURSDAY MARCH 16

SESSION 2: VULNERABILITIES OVERVIEW / MANAGEMENT AND COLLABORATION (Cont.)

Time	THURSDAY MARCH 16
8:00 AM	Opening Remarks
Riparian Systems Science Panel *(Moderator: Molly Cross or Eric Macknak)*	
SCIENCE	
8:15 AM	Title – TBA - native fish **Clint Muhfeld**, *US Geological Services*
8:30 AM	Fluvial Geomorphology, Floodplain connectivity **Karin Boyd**, *Applied Geomorphology, Inc.*
8:45 AM	Beaver mimicry - and shallow water recharge **Nathan Korb,** *The Nature Conservancy*
9:00 AM	***Q&A***
9:15 AM	**BREAK**
MANAGEMENT AND COLLABORATION	
9:35 AM	Watershed Resiliency and Restoration Program **Andy Lamb**, *Alberta Environment and Parks*
9:50 AM	Title - TBA **Erik Kalsta,** *Rancher Owner (Big Hole) – tentative confirmed*
10:05 AM	Putting Beavers to Work for Watershed Resiliency and Restoration **Danah Duke**, *Miistakis Institute*
10:20 AM	***Q&A***
10:35 AM	**Breakout – Riparian Systems- Vulnerabilities and Adaptations** **Product:** *Adaptations Options for key vulnerabilities selected by participants*
12:35 PM	**LUNCH (provided)**
1:35 PM	**Report out from Riparian Systems breakout**
2:05 PM	**Wrapping UP - summarize results**
2:35 PM	Closing Remarks and Acknowledgments
3:05 PM	Adjourn - Safe Travels

XIV. Appendices

A. Fish, Wildlife and Parks instream flow rights by sub-basin

Table A-1 Murphy Rights held by the Montana Department of Fish, Wildlife and Parks

Stream	Reach	Dates	Flow Rate (CFS)
Madison River	Hebgen Dam to Quake Lake	4/1-7/31	50
		8/1-3/31	500
	Quake Lake to West Fork	1/1-12/31	500
	West Fork to Ennis Lake	1/1 – 5/31	900
		6/1 – 7/15	1,400
		7/16-12/31	1,050
	Ennis Lake to Mouth	1/1 – 5/31	1,200
		6/1 – 6/30	1,500
		7/1-7/15	1,423
		7/16-12/31	1,300
West Gallatin River	Yellowstone Park to Gallatin Gateway	5/16-7/15	800
		7/16-5/15	400
Gallatin River	East Fork to Mouth	5/1-5/15	947
		5/16-5/31	1,278
		6/1-6/15	1,500
		6/16-6/30	1,176
		7/1-8/31	850
		9/1-4/30	800
Missouri River	Toston Dam to Canyon Ferry Reservoir	1/1-1/31	1,500
		2/1-5/15	3,000
		5/15-6/30	4,000
		7/1-7/15	3,816
		7/16-9/14	1,500
		9/15-12/31	3,000
Smith River	Fort Logan to Sheep Creek	5/1-6/30	150
		7/1-4/30	90
	Sheep Creek to Cascade-Meagher County Line	4/1-4/30	140
		5/1-6/30	150
		7/1-8/31	140
		9/1-3/31	125
	Cascade-Meagher County Line to Hound Creek	5/1-5/15	372
		5/16-6/15	400
		6/16-6/30	398
		7/1-4/30	150

Table A-2 FWP instream flow water reservations in the Upper Missouri River Basin

BIG HOLE RIVER DRAINAGE

STREAM	REACH DESCRIPTION	DATES GRANTED	AMOUNT ALLOWED (cfs)
American Creek	Headwaters to mouth	Jan 1 – Dec 31	2.8
Bear Creek	Headwaters to mouth	Jan 1 – Dec 31	2.8
Big Hole River #1	Warm Springs Creek to Pintler Creek	Jan 1 – Dec 31	160
Big Hole River #2	Pintler Creek to the old Divide Dam	Jan 1 – Dec 31	800
Big Hole River #3	Old Divide Dam to mouth	Jan 1 – Dec 31	573
Big Lake Creek	Twin Lakes outlet to mouth	Jan 1 – Dec 31	4.7
Birch Creek	Mule Creek to mouth	Jan 1 – Dec 31	10
Bryant Creek	Headwaters to mouth	Jan 1 – Dec 31	1.4
California Creek	Headwaters to mouth	Jan 1 – Dec 31	10
Camp Creek	Headwaters to mouth	Jan 1 – Dec 31	5
Canyon Creek	Canyon Lake to mouth	Jan 1 – Dec 31	5
Corral Creek	Headwaters to mouth	Jan 1 – Dec 31	1
Deep Creek	Sevenmile and Tenmile to mouth	Jan 1 – Dec 31	18
Delano Creek	Headwaters to mouth	Jan 1 – Dec 31	0.3
Divide Creek	North and East forks to mouth	Jan 1 – Dec 31	3
Fishtrap Creek	West and Middle forks to mouth	Jan 1 – Dec 31	10
Francis Creek	Sand Creek to mouth	Jan 1 – Dec 31	4
French Creek	Headwaters to mouth	Jan 1 – Dec 31	3
Governor Creek	Headwaters to mouth	Jan 1 – Dec 31	4
Jacobsen Creek	Tahepia Lake to mouth	Jan 1 – Dec 31	14
Jerry Creek	Headwaters to mouth	Jan 1 – Dec 31	7
Johnson Creek	Schultz Creek to Forest Service boundary	Jan 1 – Dec 31	13
Joseph Creek	Anderson Creek to mouth	Jan 1 – Dec 31	5
LaMarche Creek	West and Middle forks to mouth	Jan 1 – Dec 31	11
Miner Creek	Upper Miner Lakes to mouth	Jan 1 – Dec 31	9
Moose Creek	Headwaters to mouth	Jan 1 – Dec 31	9
Mussigbrod Creek	Hell Roaring Creek to uppermost existing diversion point in NWSENW Section 9 T1S R16W	Jan 1 – Dec 31	10
NF Big Hole River	Ruby and Trail creeks to mouth	Jan 1 – Dec 31	30
Oregon Creek	Headwaters to mouth	Jan 1 – Dec 31	0.3
Pattengail Creek	Sand Lake to mouth	Jan 1 – Dec 31	12
Pintler Creek	Oreamnos Lake to mouth	Jan 1 – Dec 31	10
Rock Creek	Beaverhead National Forest boundary to mouth	Jan 1 – Dec 31	5
Ruby Creek	Pioneer and WF Ruby creeks to mouth	Jan 1 – Dec 31	4
Sevenmile Creek	Headwaters to mouth	Jan 1 – Dec 31	1.8
Seymour Creek	Upper Seymour Lake to mouth	Jan 1 – Dec 31	13
Sixmile Creek	Headwaters to mouth	Jan 1 – Dec 31	1.6
SF Big Hole River	Skinner Lake to mouth	Jan 1 – Dec 31	22
Steel Creek	Headwaters to mouth	Jan 1 – Dec 31	6
Sullivan Creek	Headwaters to mouth	Jan 1 – Dec 31	4
Swamp Creek	Yank Swamp to mouth	Jan 1 – Dec 31	8
Tenmile Creek	Tenmile Lakes to mouth	Jan 1 – Dec 31	3.8
Trail Creek	Headwaters to mouth	Jan 1 – Dec 31	6
Trapper Creek	Trapper Lake to mouth	Jan 1 – Dec 31	1.8
Twelvemile Creek	Headwaters to mouth	Jan 1 – Dec 31	1.2
Warm Springs Creek	West and East forks to mouth	Jan 1 – Dec 31	5
Willow Creek	Tendoy Lake to mouth	Jan 1 – Dec 31	16
Wise River	Mono and Jacobson creeks to mouth	Jan 1 – Dec 31	20
Wyman Creek	Headwaters to mouth	Jan 1 – Dec 31	7

Table A-2(con't): FWP instream flow water reservations in the Upper Missouri River Basin

GALLATIN RIVER DRAINAGE

STREAM	REACH DESCRIPTION	DATES GRANTED	AMOUNT ALLOWED (cfs)
Baker Creek	Heeb Lane Bridge to mouth	Jan 1 – Dec 31	14
Ben Hart Creek	Headwaters to mouth	Jan 1 – Dec 31	29
Big Bear Creek	Headwaters to mouth	Jan 1 – Dec 31	2
Bridger Creek	Headwaters to mouth	Jan 1 – Dec 31	14
Cache Creek	Headwaters to mouth	Jan 1 – Dec 31	2.6
EF Hyalite Creek	Heather Lake to Hyalite Reservoir	Jan 1 – Dec 31	7
East Gallatin River #1	Rocky and Sourdough creeks to Bozeman STP outlet	Jan 1 – Dec 31	42.4
East Gallatin River #2	Bozeman STP outlet to Thompson Spring Creek	Jan 1 – Dec 31	90
East Gallatin River #3	Thompson Spring Creek to mouth	Jan 1 – Dec 31	170
Gallatin River #1	Yellowstone NP boundary to WF Gallatin River	Jan 1 – Dec 31	170
Gallatin River #2	WF Gallatin River to East Gallatin River	Jan 1 – Dec 31	400
Gallatin River #3	East Gallatin River to mouth	Jan 1 – Dec 31	533.5
Hell Roaring Creek	NF Hell Roaring Creek to mouth	Jan 1 – Dec 31	16
Hyalite (Middle) Creek #1	Middle Creek Dam to Middle Creek Ditch intake	Jan 1 – Dec 31	28
Hyalite (Middle) Creek #2	1-90 bridge near Belgrade to mouth	Jan 1 – Dec 31	16
MF of the WF Gallatin R.	Headwaters to NF of the WF Gallatin River	Jan 1 – Dec 31	3
Porcupine Creek	NF Porcupine Creek to mouth	Jan 1 – Dec 31	4.5
Reese Creek	Bill Smith Creek to mouth	Jan 1 – Dec 31	5
Rocky Creek	Jackson Creek to Sourdough Creek	Jan 1 – Dec 31	18
Sourdough (Bozeman) Creek	Mystic Reservoir to mouth	Jan 1 – Dec 31	11
South Cottonwood Creek	Jim Creek to Hart Ditch headgate	Jan 1 – Dec 31	14
SF Spanish Creek	Falls Creek to mouth	Jan 1 – Dec 31	15
SF of the WF Gallatin River	Headwaters to mouth	Jan 1 – Dec 31	5
Spanish Creek	North and South forks to mouth	Jan 1 – Dec 31	70
Squaw Creek	Headwaters to mouth	Jan 1 – Dec 31	12
Taylor Fork	Tumbledown Creek to mouth	Jan 1 – Dec 31	36
Thompson Spring Creek	County road crossing in TI1N R5E Sec 30 to mouth	Jan 1 – Dec 31	29
WF Gallatin River	Middle and North forks to mouth	Jan 1 – Dec 31	26
WF Hyalite Creek	Hyalite Lake to Hyalite Reservoir	Jan 1 – Dec 31	12

JEFFERSON AND BOULDER RIVER DRAINAGES

STREAM	REACH DESCRIPTION	DATES GRANTED	AMOUNT ALLOWED (cfs)
Boulder River #1	West and South forks to High Ore Creek	Jan 1 – Dec 31	20
Boulder River #2	High Ore Creek to Cold Spring	Jan 1 – Dec 31	8
Boulder River #3	Cold Spring to mouth	Jan 1 – Dec 31	47
Halfway Creek	Headwaters to canyon	Jan 1 – Dec 31	1.9
Hells Canyon Creek	Headwaters to mouth	Jan 1 – Dec 31	3.6
Jefferson River	Headwaters to Madison River	Jan 1 – Dec 31	1,095.5
Little Boulder River	Moose Creek to mouth	Jan 1 – Dec 31	7
North Willow Creek	Hollow Top Lake to mouth	Jan 1 – Dec 31	7
South Boulder River	Curly Creek to mouth	Jan 1 – Dec 31	12
South Willow Creek	Granite Lake to mouth	Jan 1 – Dec 31	14
Whitetail Creek	Whitetail Reservoir to mouth	Jan 1 – Dec 31	3
Willow Creek	North and South Willow creeks to mouth	Jan 1 – Dec 31	14
Willow Spring Creek	Headwaters to mouth	Jan 1 – Dec 31	9.2

MADISON RIVER DRAINAGE

STREAM	REACH DESCRIPTION	DATES GRANTED	AMOUNT ALLOWED (cfs)
Antelope Creek	Headwaters to mouth	Jan 1 – Dec 31	14
Beaver Creek	Wyethia Creek to Earthquake Lake	Jan 1 – Dec 31	22
Black Sand Spring Creek	Black Sand Spring to SF Madison River	Jan 1 – Dec 31	18.7
Blaine Spring Creek	Ennis National Fish Hatchery to mouth	Jan 1 – Dec 31	23
Cabin Creek	Gully Creek to Madison River	Jan 1 – Dec 31	22
Cherry Creek	Headwaters to mouth	Jan 1 – Dec 31	15
Cougar Creek	Yellowstone NP boundary to mouth	Jan 1 – Dec 31	24
Duck Creek	Yellowstone NP boundary to Hebgen Reservoir	Jan 1 – Dec 31	23
Elk River	Headwaters to mouth	Jan 1 – Dec 31	28
Grayling Creek	Yellowstone NP boundary to Hebgen Reservoir	Jan 1 – Dec 31	34
Hot Springs Creek	North and Middle forks to mouth	Jan 1 – Dec 31	5.5
Indian Creek	Raw Liver Creek to mouth	Jan 1 – Dec 31	48
Jack Creek	Lone Creek to mouth	Jan 1 – Dec 31	24
Madison River #1	Yellowstone NP boundary to Hebgen Reservoir	Jan 1 – Dec 31	245
Madison River #2	Hebgen Dam to West Fork	Jan 1 – Dec 31	502.5
Madison River #3	West Fork to Ennis Reservoir	Jan 1 – Dec 31	716
Madison River #4	Ennis Dam to mouth	Jan 1 – Dec 31	825
Moore Creek	Fletcher Creek to mouth	Jan 1 – Dec 31	1.4
North Meadow Creek	Headwaters to mouth	Jan 1 – Dec 31	18
O'Dell Creek	Headwaters to mouth	Jan 1 – Dec 31	98
Red Canyon Creek	Headwaters to Hebgen Reservoir	Jan 1 – Dec 31	2.9
Ruby Creek	Beartrap Canyon to mouth	Jan 1 – Dec 31	18
SF Madison River	Dry Canyon to Hebgen Reservoir	Jan 1 – Dec 31	92
Squaw Creek	North Fork to mouth	Jan 1 – Dec 31	14
Standard Creek	Headwaters to mouth	Jan 1 – Dec 31	10
Trapper Creek	Headwaters to Hebgen Reservoir	Jan 1 – Dec 31	3.2
Watkins Creek	Coffin Creek to Hebgen Reservoir	Jan 1 – Dec 31	5.5
WF Madison River	Fox Creek to mouth	Jan 1 – Dec 31	42

RED ROCK-BEAVERHEAD DRAINAGE

STREAM	REACH DESCRIPTION	DATES GRANTED	AMOUNT ALLOWED (cfs)
Bear Creek	Headwaters to BLM boundary	Jan 1 – Dec 31	6.5
Beaverhead River #1	Clark Canyon to East Bench Div Dam at Barretts	Jan 1 – Dec 31	200
Beaverhead River #2	East Bench Diversion Dam at Barretts to mouth	Jan 1 – Dec 31	200
Big Sheep Creek	Cabin and Nicholia creeks to mouth	Jan 1 – Dec 31	33
Black Canyon Creek	Headwaters to mouth	Jan 1 – Dec 31	2.5
Blacktail Deer Creek	MF and WF to uppermost existing diversion point in SENENE Section 29 T8S R8W	Jan 1 – Dec 31	27
Bloody Dick Creek	Swift Lake outlet to mouth	Jan 1 – Dec 31	20
Browns Canyon Creek	Headwaters to mouth	Jan 1 – Dec 31	2.3
Cabin Creek	Headwaters to mouth	Jan 1 – Dec 31	0.4
Corral Creek	Headwaters to mouth	Jan 1 – Dec 31	6
Deadman Creek	Deadman Lake to mouth	Jan 1 – Dec 31	4.5
EF Blacktail Deer Creek	Headwaters to mouth	Jan 1 – Dec 31	18
EF Clover Creek	Headwaters to mouth	Jan 1 – Dec 31	4.4
EF Dyce Creek	Headwaters to mouth	Jan 1 – Dec 31	1.4
Frying Pan Creek	Headwaters to mouth	Jan 1 – Dec 31	1.6
Grasshopper Creek	Blue Creek to mouth	Jan 1 – Dec 31	25.8

Hell Roaring Creek	Headwaters to mouth	Jan 1 – Dec 31	15
Horse Prairie Creek	Headwaters to mouth	Jan 1 – Dec 31	20
Indian Creek	Headwaters to mouth	Jan 1 – Dec 31	0.2
Jones Creek	Headwaters to Lakeview Road crossing	Jan 1 – Dec 31	1.9
Long Creek	Jones Creek to mouth	Jan 1 – Dec 31	3.4
Medicine Lodge Creek	Bear Canyon to mouth	Jan 1 – Dec 31	10
Narrows Creek	Spring in T13S R1E Sec 18A to Elk Lake	May 1 – July 15 July 16 – Apr 30	1.2 0.5
Odell Creek	Headwaters to Lower Red Rock Lake	Jan 1 – Dec 31	11
Peet Creek	Headwaters to reservoir in T14S R4W Sec 34A	Jan 1 – Dec 31	0.9
Poindexter Slough	Springs & canal T8S R9W Sec 3, SW to Beaverhead	Jan 1 – Dec 31	57.9
Rape Creek	Headwaters to reservoir in T10S R13W Sec 4	Jan 1 – Dec 31	0.4
Red Rock Creek	Headwaters to Upper Red Rock Lake	Jan 1 – Dec 31	15
Red Rock River #1	Dam at Lower Red Rock Lake to Lima Reservoir	Jan 1 – Dec 31	55
Red Rock River #2	Lima Dam to Clark Canyon Reservoir	Jan 1 – Dec 31	60
Reservoir Creek	Headwaters to mouth	Jan 1 – Dec 31	1.5
Shenon Creek	Headwaters to BLM boundary in T10S R14W Sec 25	Jan 1 – Dec 31	0.4
Simpson Creek	Headwaters to mouth	Jan 1 – Dec 31	0.7
Tom Creek	Headwaters to Upper Red Rock Lake	Jan 1 – Dec 31	1.4
Trapper Creek	Headwaters to mouth	Jan 1 – Dec 31	0.7
WF Blacktail Deer Creek	Grays and South forks to mouth	Jan 1 – Dec 31	3
WF Dyce Creek	Headwaters to mouth	Jan 1 – Dec 31	0.7

RUBY RIVER DRAINAGE

STREAM	REACH DESCRIPTION	DATES GRANTED	AMOUNT ALLOWED (cfs)
Coal Creek	Headwaters to mouth	Jan 1 – Dec 31	3.6
Cottonwood Creek	Geyser Creek to mouth	Jan 1 – Dec 31	4
EF Ruby River	Headwaters to mouth	Jan 1 – Dec 31	3
MF Ruby River	Divide Creek to mouth	Jan 1 – Dec 31	5
Mill Creek	Outlet of Branham Lake to mouth	Jan 1 – Dec 31	10
NF Greenhorn Creek	Headwaters to mouth	Jan 1 – Dec 31	3.5
Ruby River #1	East, Middle, and West forks to Ruby Reservoir	Jan 1 – Dec 31	90
Ruby River #2	Ruby Dam to mouth	Jan 1 – Dec 31	40
Warm Springs Creek	Romy Lake outlet to mouth	Jan 1 – Dec 31	48.5
WF Ruby River	Headwaters to mouth	Jan 1 – Dec 31	3
Wisconsin Creek	Crystal Lake outlet to mouth	Jan 1 – Dec 31	6

UPPER MISSOURI RIVER AND TRIBUTARIES

STREAM	REACH DESCRIPTION	DATES GRANTED	AMOUNT ALLOWED (cfs)
Avalanche Creek	Cooney Gulch to Canyon Ferry Reservoir	Jan 1 – Dec 31	5
Beaver Creek	Headwaters in Elkhorn Mts to Canyon Ferry Reservoir	Jan 1 – Dec 31	2.8
Beaver Creek	Headwaters in Big Belt Mts to mouth	Jan 1 – Dec 31	10
Canyon Creek	Headwaters to mouth	Jan 1 – Dec 31	10
Confederate Gulch	Debauch Gulch to mouth	Jan 1 – Dec 31	5
Cottonwood Creek	Headwaters to mouth	Jan 1 – Dec 31	1
Crow Creek	Tizer and Wilson Creeks to Williams Ditch intake	Jan 1 – Dec 31	11
Deep Creek	Castle Fork to Missouri River	Jan 1 – Dec 31	9
Dry Creek	Headwaters to Broadwater Missouri Canal	Jan 1 – Dec 31	1.8
Duck Creek	Headwaters to Canyon Ferry Res.	Jan 1 – Dec 31	8
Little Prickly Pear Ck. #1	Canyon Creek to Clark Creek	Jan 1 – Dec 31	22

Little Prickly Pear Ck. #2	Clark Creek to mouth	Jan 1 – Dec 31	70
Lyons Creek	Headwaters to mouth	Jan 1 – Dec 31	10
McGuire Creek	Headwaters to mouth	May 1 – Nov 30 Dec 1 – Apr 30	8.3 4.7
Missouri River #1	Jefferson and Madison rivers to Canyon Ferry Res.	Jan 1 – Dec 31	2,400
Missouri River #2	Hauser Dam to Holter Reservoir	Jan 1 – Dec 31	2,881
Missouri River #3	Holter Dam to Great Falls	Jan 1 – Dec 31	3,327
Prickly Pear Creek #1	Rabbit Gulch to Hwy 12 bridge in East Helena	Jan 1 – Dec 31	22
Prickly Pear Creek #2	Hwy 12 bridge in East Helena to Lake Helena	Jan 1 – Dec 31	30
Sevenmile Creek	Greenhorn Creek and Skelly Gulch to mouth	Jan 1 – Dec 31	1
Sheep Creek	Headwaters of South Fork to mouth	Jan 1 – Dec 31	22
Silver Creek	Helena Valley Irrigation Canal to mouth	May 1 – Nov 30 Dec 1 – Apr 30	13 5.4
Sixteenmile Creek	Billy Creek to mouth	Jan 1 – Dec 31	20
Spokane Creek	Helena Valley Irr. Canal to mouth	May 1 – Nov 30 Dec 1 – Apr 30	4 3
Stickney Creek	North and South forks to mouth	Apr 1 – Apr 30 May 1 – May 31 June 1 – June 30 July 1 – July 31	7 34 35 7
Tenmile Creek	Headwaters to mouth	Jan 1 – Dec 31	12
Trout Creek	Springs near Vigilante Campground to mouth	Jan 1 – Dec 31	15
Virginia Creek	Headwaters to mouth	Jan 1 – Dec 31	6
Wegner Creek	Headwaters to mouth	Apr 1 – Apr 30 May 1 – May 31 June 1 – June 30 July 1 – July 31	8 41 38 8
Willow Creek	Headwaters to mouth	Jan 1 – Dec 31	3.5
Wolf Creek	Headwaters to mouth	Jan 1 – Dec 31	7

DEARBORN RIVER DRAINAGE

STREAM	REACH DESCRIPTION	DATES GRANTED	AMOUNT ALLOWED (cfs)
Dearborn River	Headwaters to mouth	Jan 1 – Dec 31	110
Flat Creek	Headwaters to mouth	Jan 1 – Dec 31	7.5
MF Dearborn River	Headwaters to mouth	Jan 1 – Dec 31	9.5
SF Dearborn River	Headwaters to mouth	Jan 1 – Dec 31	11.5

SMITH RIVER DRAINAGE

STREAM	REACH DESCRIPTION	DATES GRANTED	AMOUNT ALLOWED (cfs)
Big Birch Creek	Headwaters to mouth	Jan 1 – Dec 31	11
Eagle Creek	Headwaters to mouth	Jan 1 – Dec 31	2.5
Hound Creek	EF Hound Creek and Middle Creek to mouth	Jan 1 – Dec 31	35
Newlan Creek	Headwaters to mouth	Jan 1 – Dec 31	3.8
NF Deep Creek	Headwaters to rock cascades	Jan 1 – Dec 31	1
NF Smith River	Headwaters to mouth	Jan 1 – Dec 31	9
Rock Creek	Headwaters to mouth	Jan 1 – Dec 31	11
Sheep Creek	Headwaters to mouth	Jan 1 – Dec 31	35
Smith River #1	North and South Forks to Sheep Creek	Jan 1 – Dec 31	78.5
Smith River #2	Sheep Creek to Hound Creek	Jan 1 – Dec 31	150
Smith River #3	Hound Creek to mouth	Jan 1 – Dec 31	80

SF Smith River	Headwaters to mouth	Jan 1 – Dec 31	7
Tenderfoot Creek	Headwaters to mouth	Jan 1 – Dec 31	15

SUN RIVER DRAINAGE

STREAM	REACH DESCRIPTION	DATES GRANTED	AMOUNT ALLOWED (cfs)
Elk Creek	Headwaters to mouth	Jan 1 – Dec 31	16
Ford Creek	Headwaters to mouth	Jan 1 – Dec 31	12
NF Willow Creek	Headwaters to mouth	Jan 1 – Dec 31	3
Sun River #1	Diversion Dam to Elk Creek	Jan 1 – Dec 31	100
Sun River #2	Elk Creek to mouth	Jan 1 – Dec 31	130
Willow Creek	Headwaters to mouth	Jan 1 – Dec 31	3

BELT CREEK DRAINAGE

STREAM	REACH DESCRIPTION	DATES GRANTED	AMOUNT ALLOWED (cfs)
Belt Creek #1	Headwaters to Big Otter Creek	Jan 1 – Dec 31	90
Belt Creek #2	Big Otter Creek to Missouri River	Jan 1 – Dec 31	35
Big Otter Creek	Whiskey Spring Coulee to Belt Creek	Jan 1 – Dec 31	5
Dry Fork Belt Creek	Galena and Oti Park Creek to Belt Creek	Jan 1 – Dec 31	7
Logging Creek	Headwaters to Belt Creek	Jan 1 – Dec 31	6
Pilgrim Creek	Headwaters to Belt Creek	Jan 1 – Dec 31	8
Tillinghast Creek	Headwaters to Belt Creek	Jan 1 – Dec 31	5.5

MIDDLE MISSOURI RIVER AND TRIBUTARIES

STREAM	REACH DESCRIPTION	DATES GRANTED	AMOUNT ALLOWED (cfs)
Cow Creek	NF and SF to County bridge	Jan 1 – Dec 31	4.5
Highwood Creek	Headwaters to Hwy 228 Bridge at Highwood	Jan 1 – Dec 31	10
Missouri River #4	Great Falls to Maris River	Jan 1 – Dec 31	3,876

MARIAS RIVER DRAINAGE

STREAM	REACH DESCRIPTION	DATES GRANTED	AMOUNT ALLOWED (cfs)
Badger Creek	N and S Badger creeks to Forest/Blackfeet Reservation Boundary	Jan 1 – Dec 31	60
Birch Creek	Swift Reservoir to Hwy 358	Jan 1 – Dec 31	64
Cut Bank Creek	Blackfeet Reservation boundary to mouth	Jan 1 – Dec 31	75
Dupuyer Creek	Headwaters to mouth	Jan 1 – Dec 31	12
Marias River #1	Two Medicine River and Cut Bank Creek to head of Tiber Reservoir	Jan 1 – Dec 31	200
Marias River #2	Tiber Dam to Circle Bridge (Hwy 223)	Jan 1 – Dec 31	419.5
Marias River #3	Circle Bridge (Hwy 223) to mouth	Jan 1 – Dec 31	488.5
North Badger Creek	Headwaters to mouth	Jan 1 – Dec 31	14
NF Dupuyer Creek	Headwaters to mouth	Jan 1 – Dec 31	12
South Badger Greek	Headwaters to mouth	Jan 1 – Dec 31	40
SF Dupuyer Creek	Headwaters to mouth	Jan 1 – Dec 31	6
SF Two Medicine River	Headwaters to Forest/Blackfeet Reservation Boundary	Jan 1 – Dec 31	16

TETON RIVER DRAINAGE

STREAM	REACH DESCRIPTION	DATES GRANTED	AMOUNT ALLOWED (cfs)
Deep Creek	Headwaters to mouth	Jan 1 – Dec 31	18
McDonald Creek	Headwaters to mouth	Jan 1 – Dec 31	10
NF Deep Creek	Headwaters to mouth	Jan 1 – Dec 31	7.2
SF Deep Creek	Headwaters to mouth	Jan 1 – Dec 31	6.9
Spring Creek	Headwaters to mouth	Jan 1 – Dec 31	4.5
Teton River	Headwaters to discharge from Priest Butte Lake	Jan 1 – Dec 31	35

LAKES AND SWAMPS

STREAM	REACH DESCRIPTION	DATES GRANTED	AMOUNT ALLOWED (af/yr)
Bean Lake	Sec. 18C and 19B, T18N, R6W, Sec. 13D and 24A, T18N, R7W	Jan 1 – Dec 31	2,649
Antelope Butte Swamp	North 1/2 Sec. 28, T26N, R8W	Jan 1 – Dec 31	460

Table A-3 FWP public recreation claims

STREAM	REACH DESCRIPTION	PERIOD OF USE	AMOUNT ALLOWED (cfs)
Beaverhead River	Grasshopper Creek to Clark Canyon Dam	Jan 1 – Dec 31	200
Beaverhead River	Clark Canyon Dam to the confluence with Big Hole River	Jan 1 – Dec 31	25