Integrated Water Resource Planning and Management Guide

for Montana Municipalities

2019

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1.0 INTRODUCTION

Integrated water resource planning (IWRP) and management is a continuous process of evaluating and documenting water supply, demand, quality, financial planning, environmental factors, and water resource alternatives to effectively manage public water systems (PWS) and prepare for the future.

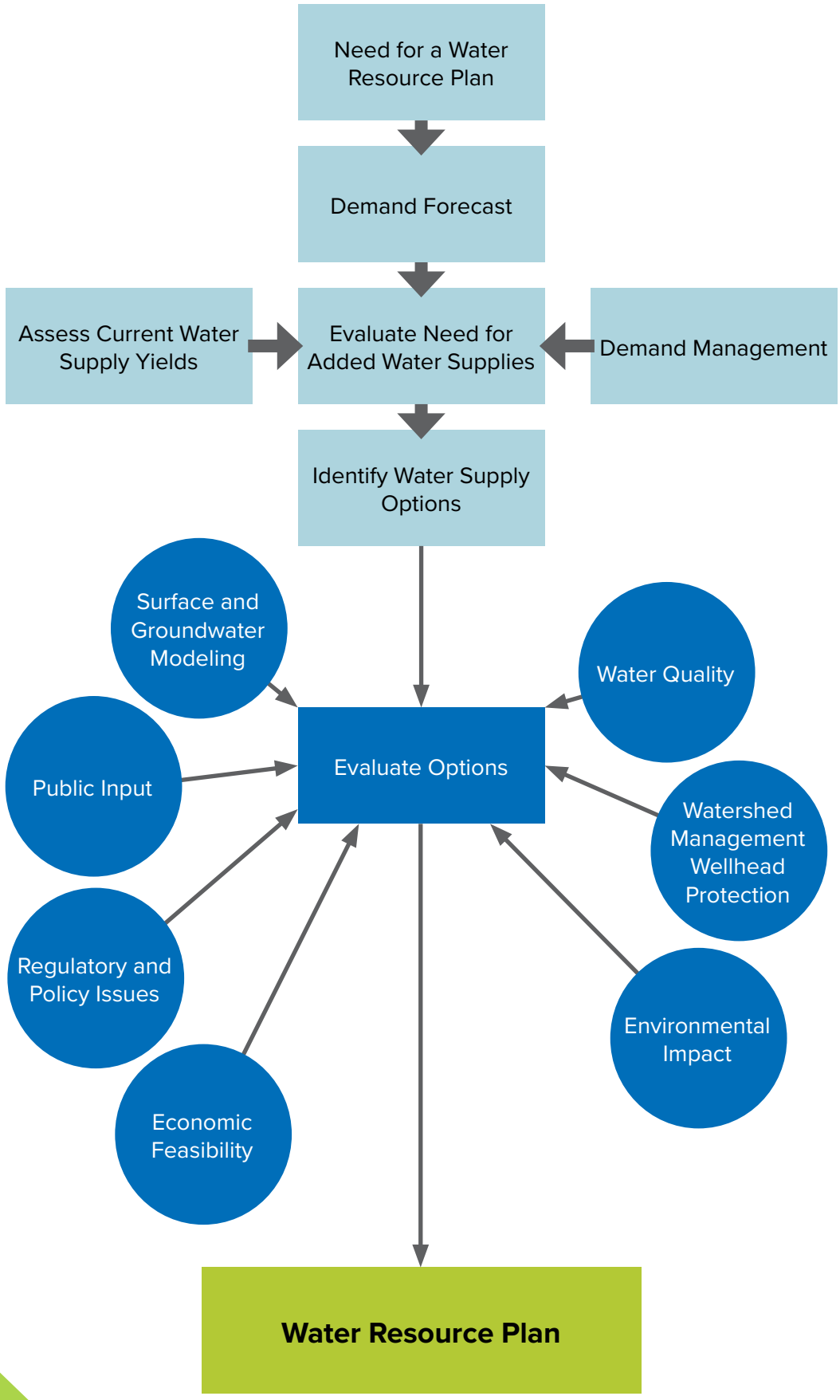
The IWRP process can be used at the local, county or regional level to support the water planning and management process to meet an area's specific water needs. Many factors affect the supply and demand for water in an area, and the IWRP process can help to identify and plan for effective water management strategies within a specific location or PWS.

In many areas, increasing population and water demands are stressing public water supplies. Many communities' water sources and supplies are also increasingly unpredictable due to factors such as climate change and more extreme drought, wildfires, water rights contests, and infrastructure failures. These stressors and uncertainties require long-term regional planning to optimize water resource use.

The IWRP process can provide management strategies and guidance to help PWS improve water supply resilience and reliability. A primary component of the IWRP process includes an evaluation of the PWS to identify current water demand, assess potential vulnerabilities, determine the basis for projecting future water demands, compare the projected water demands to the amount of water available from existing sources, and quantify the amount and at what point in time the PWS will need to acquire additional sources of water.

For example, the City of Bozeman used the IWRP process to implement better water conservation measures as well as develop and evaluate a broad range of water supply management options to meet future water supply needs.

An example of the IWRP process as presented by the American Water Works Association (AWWA) in its Water Resources Planning Manual of Water Supply Practices is shown in the figure on page 4. However, since every model and system are different and the planning process changes depending on a system's specific needs and goals, not all IWRP planning models are the same. The approach presented here is similar to the AWWA IWRP process.


Need for a Water Resource Plan
Demand Forecast
Assess Current Water Supply Yields
Evaluate Need for Added Water Supplies
Demand Management
Identify Water Supply Options
Surface and Groundwater Modeling
Water Quality
Public Input
Evaluate Options
Watershed Management Wellhead Protection
Regulatory and Policy Issues
Environmental Impact
Economic Feasibility
Water Resource Plan

The IWRP process can range from a comprehensive and detailed water resources evaluation using software models to simple assessments summarizing existing water demand, supply, and operations and outlining future goals. Many public water systems do not have the financial, technical, or human capacity to complete a comprehensive water resources plan. **The purpose of this IWRP guide is to help these systems assess their water supply and water demand to identify potential vulnerabilities and develop long-term solutions. Moderate planning is infinitely more valuable than no planning.**

This document is an Integrated Water Resources Planning kick-starter for Montana PWS that provides:

- An overview of water resources planning and management concepts, tools and evaluation methods.
- A logical water resources planning process to support Montana PWS in future planning and effective management of water resources, while allowing for variances in geographical location, size, water sources, and financial resources.
- Planning tools (checklists, worksheets, references, examples, and "how-to" guidance) for Montana PWS to start the IWRP process.
- Additional and relevant IWRP resources to enable PWS to develop more detailed IWRPs.

This guidance document consists of the following sections:

1. **Water Supply** - comprised of water supply assessment and monitoring strategies and guidance on the key components of performing water supply and water rights evaluations and a vulnerability assessment for your system.

2. **Water Demand** - description of the water demand evaluation process to better understand water use patterns by processing historical water demand data.

3. **Other Planning Approaches** - description of planning approaches including water use efficiency/water conservation planning, drought planning and source water protection planning.

Getting Started Checklist

- Identify and describe main objectives
- Gather and organize historical water supply data
- Gather and organize water rights information
- Identify the most critical vulnerabilities and complete vulnerability assessment form
- Gather and organize historical water demand data
- Identify data gaps
- Complete water demand projection calculations
- Engage the community
- Solicit participation from local agencies and nongovernmental organizations as applicable

2.0 WATER SUPPLY

A water supply evaluation analyzes existing water supplies to more formally define the yield and to assess the reliability of the system to meet future demands. A key component of the water supply evaluation process is to categorize and evaluate existing water rights with respect to quantity and sources to assess water supply against water demand. Alternative water supply sources can be identified and evaluated during this process.

Water Supply Monitoring

Water supply monitoring utilizes a variety of resources depending on a community's specific setting and water source. Tools such as stream gage data, reservoir levels, groundwater levels, soil moisture, snowpack data, and climatological variables may be useful to monitor:

- Streamflow monitoring data throughout the state can be accessed using the United States Geological Survey (USGS) website showing current water conditions.
  https://www.usgs.gov/centers/water-dashboard/surface?state=mt
- Additional streamflow monitoring data can be obtained through the Surface Water Assessment and Monitoring Program initiated by Department of Natural Resources and Conservation (DNRC) and the Montana Bureau of Mines and Geology
  http://www.mbmg.mtech.edu/swamp/swamp.html
- Reservoir level monitoring is site-specific. Many state and federal reservoir levels/volumes are available online both from the Montana Department of Natural Resources and Conservation and the U.S. Bureau of Reclamation websites.
  http://dnrc.mt.gov/divisions/water/projects/docs/reservoir-storage
- Groundwater monitoring data throughout the state can be accessed using the MT Bureau of Mines and Geology map
  http://data.mbmg.mtech.edu/mapper/mapper.asp?view=Wells&
- Snowpack can be monitored in Montana using the National Resources Conservation Service (NRCS) National Water and Climate Center's website: https://www.wcc.nrcs.usda.gov/snow/snow_map.html
- The Montana Climate Office is developing a cooperative statewide soil moisture monitoring network (Montana Mesonet):
  https://climate.umt.edu/products/soilmoisture/default.php
- Gridded climatological variables are readily available through the Climate Engine web application:
  http://climateengine.org/
- Applied Climate Information System (ACIS) Climate Maps: https://hprcc.unl.edu/maps.php?map=ACISClimateMaps
- Parameter-elevation Regressions on Independent Slopes Model (PRISM): http://www.prism.oregonstate.edu/comparisons/

Several regional drought indices are readily available online to assess drought conditions, including:

- The U.S. Drought Monitor https://droughtmonitor.unl.edu/ is a composite index based on measurements of hydrologic, climatic, and soil conditions. It incorporates the Palmer Drought Severity Index (PDSI), Standard Precipitation Evapotransporation Index (SPEI), USGS weekly streamflow, Climate Prediction Center's (CPC) soil moisture model, and objective drought indicator blends. Most importantly, it relies on expert input from a subcommittee of the Montana Governor's Drought and Water Supply Advisory Committee. Members of this subcommittee represent several state and federal agencies, and the MT Climate office, tribes, universities, and others who correspond with the U.S. Drought Monitor map authors weekly to assess the latest drought conditions.

- The Standard Precipitation Evapotranspiration Index (SPEI) http://spei.csic.es/map/maps.html#months=1#month=3#year=2019 is a probability-based index that utilizes historical rainfall data and potential evapotranspiration. The SPEI can be computed for different time scales ranging from one month to forty-eight months in order to capture short-term and long-term drought conditions.
- Evaporative Demand Drought Index (EDDI) is an early warning tool for drought onset based on anomalous atmospheric demand. https://www.esrl.noaa.gov/psd/eddi/
- VegDRI maps provide regional to sub-county information about drought's effects on vegetation. The calculations utilize satellite-based observation of vegetation conditions, climate data, and other biophysical information including land cover, land use, soil characteristics, and ecological setting. https://vegdri.unl.edu/

A more detailed description of these national drought indices is provided in the table below.

DROUGHT INDEX	PARAMETERS	ADVANTAGES	DISADVANTAGES
US Drought Monitoring	• Precipitation • Temperature • Evapotranspiration • Soil Recharge • Runoff • Moisture Loss • Snow Water Content	• Includes multiple parameters • Provides consistent drought conditions	• Complex calculations • Broad coverage area • Does not capture local conditions
Standard Precipitation Evapotranspiration Index (SPEI)	• Rainfall • Evapotranspiration	• Can be computed for different time scales	• Excludes snowfall
Evaporative Demand Drought Index (EDDI)	• Atmospheric evaporative demand	• Can capture signals of water stress at weekly and monthly timescales	• Limited data to atmospheric demand

Drought Conditions

Additional drought monitoring resources include the following:

- National Integrated Drought Information System https://www.drought.gov/drought/states/montana
- Montana DNRC Drought Management http://dnrc.mt.gov/divisions/water/drought-management
- US Drought Monitor https://droughtmonitor.unl.edu/Maps/MapArchive.aspx
- Montana Drought Impact Reporter- local reports on moisture conditions http://nris.mt.gov/droughtimpacts
- Westwide Drought Tracker https://wrcc.dri.edu/wwdt/current.php?folder=spi3&region=ww

2.1 WATER RIGHTS EVALUATION

Many public water systems have water rights that are not much greater than their current or future estimated water demand. All systems should perform an evaluation to understand and document their existing water rights. Understanding water rights is crucial to plan appropriately for increased water use and future growth. Systems also need to account for seasonal water rights in the overall water rights portfolio, since seasonal water rights may be more restrictive. Understanding the impact of water rights on operation of a water system is critical to complying with Montana Water Law.

Montana Water Law Overview

As defined in the Montana Constitution, Montana waters are the property of the state, and individuals can acquire the H2O rights to use the water for a beneficial use. Montana water law is based on the Prior Appropriation Doctrine, which means water rights are ranked according the date when the use of the water began. The priority date of a water right is an important component to consider since water users with the earlier priority date can divert - or use - their claim before other water users with later priority dates. During water shortages, senior water right holders can initiate a call on junior water users. In some areas with perennial water shortages, water users have petitioned their county district courts to appoint one or more water commissioners to distribute water based on priority. This gives commissioners legal authority to adjust headgates and reduce or cut off water allocation to junior users when water supply is limited.

Every water right has these components (from: "Guide to Montana Water Management" http://waterquality.montana.edu/resources/files_images/who_does_what_with_montanas_water.pdf):

- Owner(s)
- Priority date
- Type of historic right (decreed, filed or use right)
- Purpose (and irrigation type where appropriate)
- Flow rate (if appropriate for purpose)
- Volume (if appropriate for purpose)
- Maximum acres (for irrigation, lawn and garden)
- Source name and type
- Point(s) and mean(s) of diversion (including reservoir specifics if appropriate)
- Period of use
- Place of use

Some watershed basins in Montana have been closed to new appropriations of water rights, which prevents water users from filing applications for new water rights from the State of Montana without adequate means for mitigation.

Public water systems should understand their water rights and how they impact their overall operations and long-term planning. It is strongly recommended that every PWS go through the following steps to understand their water rights:

1. Research and record current water rights information using the MT DNRC water right query system for detailed water rights information: http://wrqs.dnrc.mt.gov/default.aspx
2. Complete the following water rights table. Document water rights and distribute internally so that the key PWS officials understand instantaneous and annual water right limitations, including, period of use restrictions as applicable:

WATER RIGHT ID NUMBER	WATER SOURCE	PRIORITY DATE	PERIOD OF USE	MAXIMUM INSTANTANEOUS WITHDRAWAL RATE (cfs)	MAXIMUM ANNUAL USE (ac-ft)
			TOTAL		

3. If some or all water rights are seasonal, develop a seasonal chart to easily illustrate water rights throughout the year. Seasonal demands can be added to the chart to ensure the PWS does not exceed its available water rights.

Water Reservations

Montana's water reservation law provides an opportunity to legally allocate water for future consumptive uses as well as to maintain instream flows to protect water rights, aquatic life, and water quality. The state, any political subdivision or agency of the state, or the United States or any agency of the United States may apply to the Montana DNRC to acquire a water reservation for existing or future beneficial uses, or to maintain a minimum flow, level, or quality of water for a time that the MT DNRC designates. Reservations include minimum instream flow for fisheries, municipal reservations, reservations for irrigation, and reservations for multi-purpose use.

As defined by the DNRC, "The (water) reservation is intended to run concurrently with and overlap, rather than run consecutively with, any other right to the use of water claimed by the reservant but not perfected to the effective date of the adoption of the reservation." Therefore, the DNRC recommends that all appropriations of water granted after the date that the reservation was issued count against the awarded reservation flow and volume for the individual municipalities.

All communities should know if they have water reservations and what volume is reserved. The reservations for each municipality in Montana can be obtained on DNRC's website: http://dnrc.mt.gov/divisions/water/water-rights/docs/water-reservations/dnrc-summary-report2_recommendations_webversion.pdf

2.2 VULNERABILITY ASSESSMENT

The purpose of a vulnerability assessment is to evaluate the reliability of a water system and the factors that pose risk to the source, supply, treatment and distribution systems. The vulnerability assessment is intended to identify the most critical vulnerabilities, so a system can develop and implement risk mitigation strategies. It is important to assess a wide range of threats and potential impacts. A rational first step consists of developing a list of potential weaknesses or threats to your water system, and summarizing the hazards and impacts to the system if there is a critical failure or shortage event.

Some of the more common vulnerabilities include:

- **Water rights** - If demand within a PWS is encroaching on existing water rights and the PWS has no water reservation, then the supply is vulnerable to growth pressure or increased demand. If the PWS is in a closed basin then the vulnerability is more critical.
- **Seasonal water rights** - Use periods where water rights flow or volume are lowest to assess PWS capacity.
- **Junior water rights** - Subject to calls by senior water rights holders when there is a shortage.
- **Water source / supply diversity** - A single surface water source is more vulnerable to drought or infrastructure failures than multiple sources, especially where one source is groundwater.
- **Reservoir size** - Is year-over-year storage capacity present, or could one severe drought year result in a water shortage?
- **Size of river** - Is the source a small stream versus a large river? Smaller rivers or streams can be more vulnerable to localized drought conditions of droughts of short duration.
- **Reliance on snowpack** - Timing and duration of runoff impacts to water supply.
- **Groundwater supply**
  - How large is the aquifer relative to the PWS?
  - What is the reliable, or firm, yield versus demand. Firm yield is the maximum quantity of water that can be delivered by a spring or reservoir during a severe drought.
  - The water right (paper water) may not reflect the actual, firm yield.
  - If budgets allow, consider having the firm yield of your watershed or aquifer estimated by a hydrologist or hydrogeologist.
- **Number of water users** and other water demands on water source, including communities, industry power generators, and irrigators.
- **Climate change**
  - Is the PWS supply susceptible to prolonged changes in weather patterns and impacts to H2O supply?
  - PWS managers should apply a safety factor for climate change when evaluating firm yields.
  - If budgets allow, obtain a climate change model-based prediction of impacts on the water supply.
- **Infrastructure vulnerabilities**
  - Are there "single points of failure" in supply, treatment, transmission or distribution? For example, a water supply may be conveyed to users via single transmission pipeline of substantial length - what if there's a major break in this pipeline?

- **Water loss, or non-revenue water** - The volume of water lost between source or treatment and delivery to the customer. Ten percent water loss is a reasonable goal. Some systems have as high as 50% water loss, which may become critical in a drought.
- **Growth or tourism pressure** - Is your PWS subject to rapid increases in population or water users due to tourism?
- **Water quality impacts** - Are there significant risks of contamination of your water supply? Some examples are surface diversions near highways or refineries, or water intakes near boat docks.
- **Wildfire impacts** - Wildfires can result in plugging of surface water sources, silt / sediment loads that are untreatable, long-term degraded water quality, and landslides. Watersheds that are heavily forested and subject to heavy use are more susceptible to major wildfires, especially during droughts.
- **Invasive species** - Are intakes or infrastructure susceptible to invasive mussels or bryozoan infestation?

Climate Change Vulnerabilities

The U.S. Environmental Protection Agency developed a web-based software application tool entitled Climate Resilience Evaluation and Awareness Tool (CREAT: http://water.epa.gov/infrastructure/watersecurity/climate/creat.cfm) to assist drinking water and wastewater utility owners and operators understand potential climate change threats and assess the related risks at their individual utilities. The goals of CREAT include the following:

- Increase drinking water, wastewater, and stormwater operator awareness of potential climate change impacts on operations.
- Assist utilities to determine levels of failure and resulting consequences.
- Guide utilities through the risk assessment process.
- Inform decision-making by identifying adaptation options.
- Examine costs of adaptation options compared to economic losses resulting from climate change threats.

WATER SUPPLY VULNERABILITY	YES	NO	DESCRIPTION OF VULNERABILITY/ LIMITATION	MITIGATION PLAN TO ADDRESS VULNERABILITY
Water rights limited with no additional water reservation				
Seasonal water rights				
Susceptibility of water rights, junior rights				
Water supply - number of supplies, diversity of supply types				
Raw water storage - capacity for year over year storage				
Size of river - document minimum flow / level				
Reliance on snowpack				
Groundwater supply - size of aquifer, firm yield, well redundancy				
Other water users / demands on source / seniority				
Water loss / non-revenue water				
Experiencing high population and/or demand growth				
Climate change impacts				
History of drought or water supply shortages				
Aging infrastructure needing repair or replacement				
Single points of infrastructure failure				
Water supply contamination risk				
Susceptibility of watershed to wildfire				
Invasive species, risk and impacts				

Adapted from Colorado Water Conservation Board. "Municipal Water Efficiency Plan Guidance Document." Boulder, CO: AMEC Earth & Environmental (2012).

3.0 WATER DEMAND ASSESSMENT

3.1 WATER METERING

Water metering in this context will refer to not just the typical point-of-use metering (residences, industries, etc), but also to metering at the water supply source(s) and strategic locations throughout the distribution system. Water metering has the following benefits:

- Water metering can be used to identify water loss or inefficiencies within a water system and to discourage excessive water use. The Alliance for Water Efficiency reports that metered customers typically use 15% to 30% less water than un-metered customers.
- Point of delivery metering enables volume-based billing (as opposed to flat rates) and provides a better understanding of water use within a PWS.
- Metering data enables a PWS to more accurately predict future water demand.

Source water metering can be as simple as installing flow meters on raw water pipelines or level sensing devices on flow control structures. At a minimum, metering of treated/finished water at the source and/or introduction to the distribution system is necessary to document water use and ensure that use is within the PWS water right(s). Water supply metering can also be used to characterize seasonal water demand, although it does not reveal information regarding water loss.

Metering at the point of delivery uses inline meters with various flow measurement methods. There are several types of commonly-used water meters including displacement, turbine, electromagnetic, and others. The technology choice depends on the flow measurement installation conditions, the type of end user, the flow rates expected, and accuracy requirements. In North America, standards for manufacturing water meters are established by the American Water Works Association.

Meters can range from as little as $50 for residential meters to $5,000 for industrial sized meters, but installed costs vary more depending on new construction versus retrofits, meter box designs, and other factors.

Automatic meter reading (AMR) systems enable meters to be read remotely, often by driving near the meters with a vehicle-mounted radio that downloads data from meters with radio signal capabilities. More advanced AMR systems consist of water meters, two-way communication system, data storage, and water use data software programs.

Master metering or submetering strategies can be implemented to improve water metering data collection throughout a water system. Master metering uses a meter on a water service line for multiple end users, whereas submetering consists of installing separate water meters for individual end users within a facility.

3.2 WATER DEMAND CHARACTERIZATION

Water Demand (water use) Characterization is the process of evaluating a water system's water demand patterns. Water Demand Characterization can provide a PWS with a basis for projecting future water demands and comparing the projected water demands to the amount of water available from existing water sources. Water demand data is critical to assess the capacity of the existing water system and ensure that supply is adequate to meet demand.

Important factors influencing water demand patterns include customer population / number of connections, water rates and the rate structure, customer income, weather variables, industrial use, housing characteristics (e.g., size of lawns), frequency of billing rates and indoor versus outdoor water use.[1]

An effective Water Use Characterization typically includes:

- Characterization of historical water use patterns (e.g. water use by day, month, and year; correlation with historical population estimates, growth patterns, and weather/climate / seasonal patterns).
- Estimation of population growth within the PWS service area.
- Prediction of future water demand within the planning timeframe.

The end goal is to predict when water demand will encroach upon or potentially exceed the source water supplies, water rights, or infrastructure capacities.

Water Demand (use) is most often described in the following terms:

Average Annual Demand (AAD) - The total volume of water delivered to the system in a full year, expressed in gallons, millions of gallons (MG) or acre feet (ac-ft).

Average Daily Demand (ADD) - The total volume of water delivered to the system over a year divided by 365 days. The average use in a single day expressed in gallons per day.

- Averaged Daily Winter Demand (Winter Demand) - The gallons per day average during the months of December, January, and February when system demands are typically low. This is often considered a community's "indoor water demand," and/or the minimum amount of a water that a community needs when considering water rate structures, drought stage responses, etc.
- Average Daily Summer Demand (Summer Demand) - The gallons per day average during the months of June, July, and August when system demands are typically high due to irrigation.
- Comparing daily winter and summer demands sheds light on how much water a community uses for outdoor irrigation.

[1]Palmer, Richard N., and Kathryn V. Lundberg. "Integrated Water Resources Planning" https://www.isws.illinois.edu/iswsdocs/wsp/IWRP_Palmer_Lundberg.pdf

Maximum Month Demand (MMD) - The gallons per day average during the month with the highest water demand. The highest monthly usage typically occurs during the summer and is due to the higher evapotranspiration rate (sum of evaporation and plant transpiration) during irrigation of turf grasses and ornamental landscapes.

Maximum Day Demand (MDD) - The largest volume of water delivered to the system in a single day expressed in gallons per day. MDD is an important parameter for assessing water supply and storage capacity.

Peak Hourly Demand (PHD) - The maximum volume of water delivered to the system in a single hour expressed in gallons per minute.

Peaking Factor (PF) - The ratio of maximum flow to the average daily flow in a water system. Commonly, this is the ratio of maximum day demand to average daily demand. Typical values for peaking factors range from 2-4. Peaking factors are influenced by weather conditions, the pressure or absence of adverse water user class, and amount of precipitation.

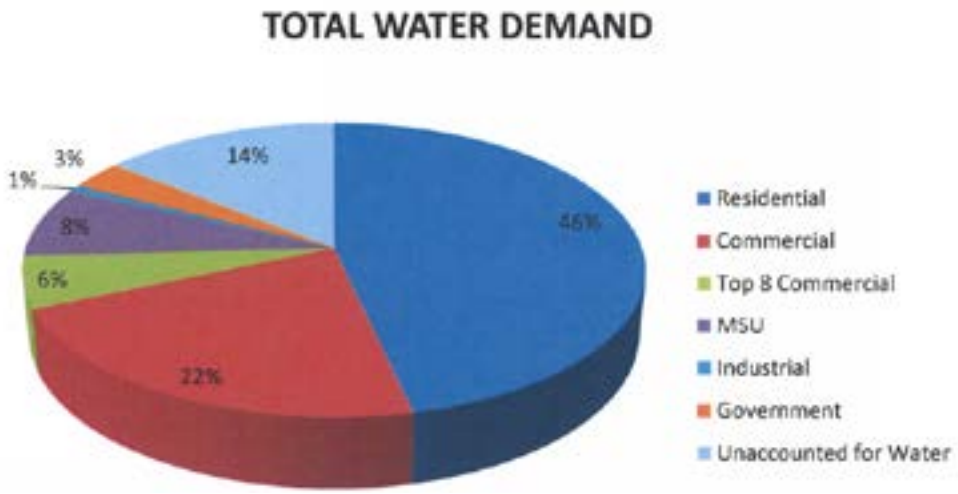
Total production - total treated water transferred to the distribution system.

Ideally, historical water use data can be obtained from metered supplies and water billing records. When a PWS has metering, the PWS should maintain a meter database and track the following parameters:

- Number and type of connections
- Total treated water produced
- Total distributed water
- Total metered water (where households are metered)
- Total billed water
- Water use by user class (i.e., residential, commercial, or industrial)
  - Estimate total water demand across each user class
  - Identify largest water users and discuss operations to understand their usage.
- Per capita water use - gallons per capita (person) per day (gpcd). Characterizing water use on a per capita basis enables a PWS to forecast future water use based on available estimates for population growth within the PWS service area.

Comparing total distributed water (at the source or treatment facility) to downstream metered or billed water provides valuable information on overall water efficiency, which can indicate if significant leaks are present in the system (90% efficiency is a typical threshold for good efficiency).

Analyzing water demand by user class can reveal where a PWS can get the best return on investment regarding water conservation. The figure below provides an easily understood visual of water use by classification for the City of Bozeman:



Whether your PWS is metered or not, knowing and understanding the largest water users within your water system is beneficial. Communication with the largest users can improve understanding of how and when water is used and strengthen planning for future water use.

Comparison of indoor and outdoor water (irrigation) use can reveal whether a PWS can benefit from a water conservation program. Indoor water use is typically characterized by water use between November and March, since irrigation is usually not a significant demand during this period. Comparing this to summer irrigation water use (usually June through September) enables the PWS to identify how much water is used for irrigation. This can be important for drought planning, as it can indicate how much water could be saved via water conservation or drought stage implementation. An example water use table is shown below.

MONTH	WATER USE (GALLONS)		
	INDOOR	OUTDOOR	TOTAL
January			
February			
March			
April	Estimate Based on Winter Total Use		
May			
June			
July			
August			
September			
October			
November			
December			
TOTALS			

Water Demand Projections

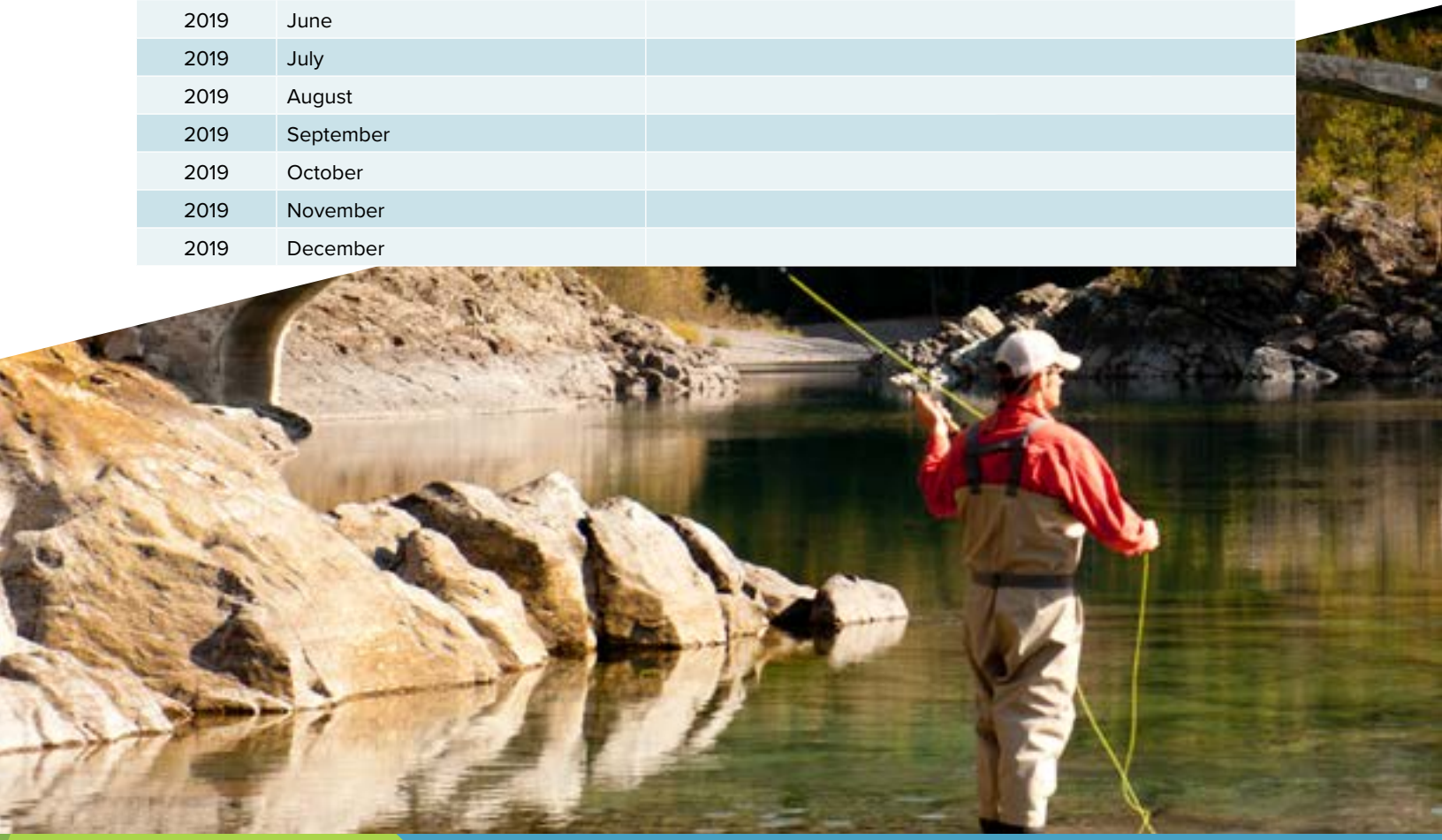
Long-term water demand projections are critical to address growth and water supply planning, and to develop appropriate capital improvements plans (CIPs). Water demand projections can be based on a variety of input data, including population, historical water use patterns, land use plans, water rates, and most importantly, the availability of water. Water demand characterization typically entails forecasting baseline (average annual) water demand, predicting peaking factors for maximum day demand, incorporating future growth policy, and ultimately balancing water use with water supply.

Water demand forecasts are most often developed by extrapolating from past water demand patterns and correlating to population estimates. This enables "per capita" projections, which defines water use by person (expressed as an average across the population, usually in units of gallons per capita day (gpcd).

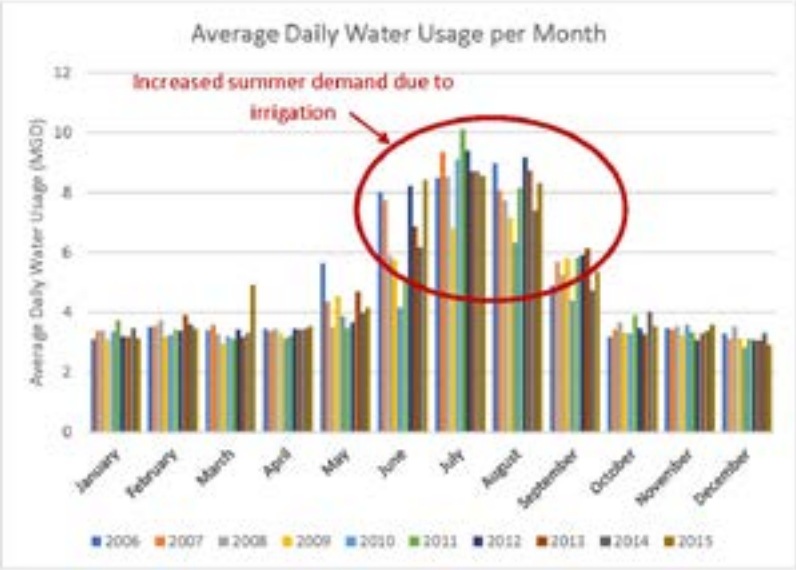
A general, step-by-step approach to developing water demand projections based on historical water usage to determine future water demands for a water system is outlined below.

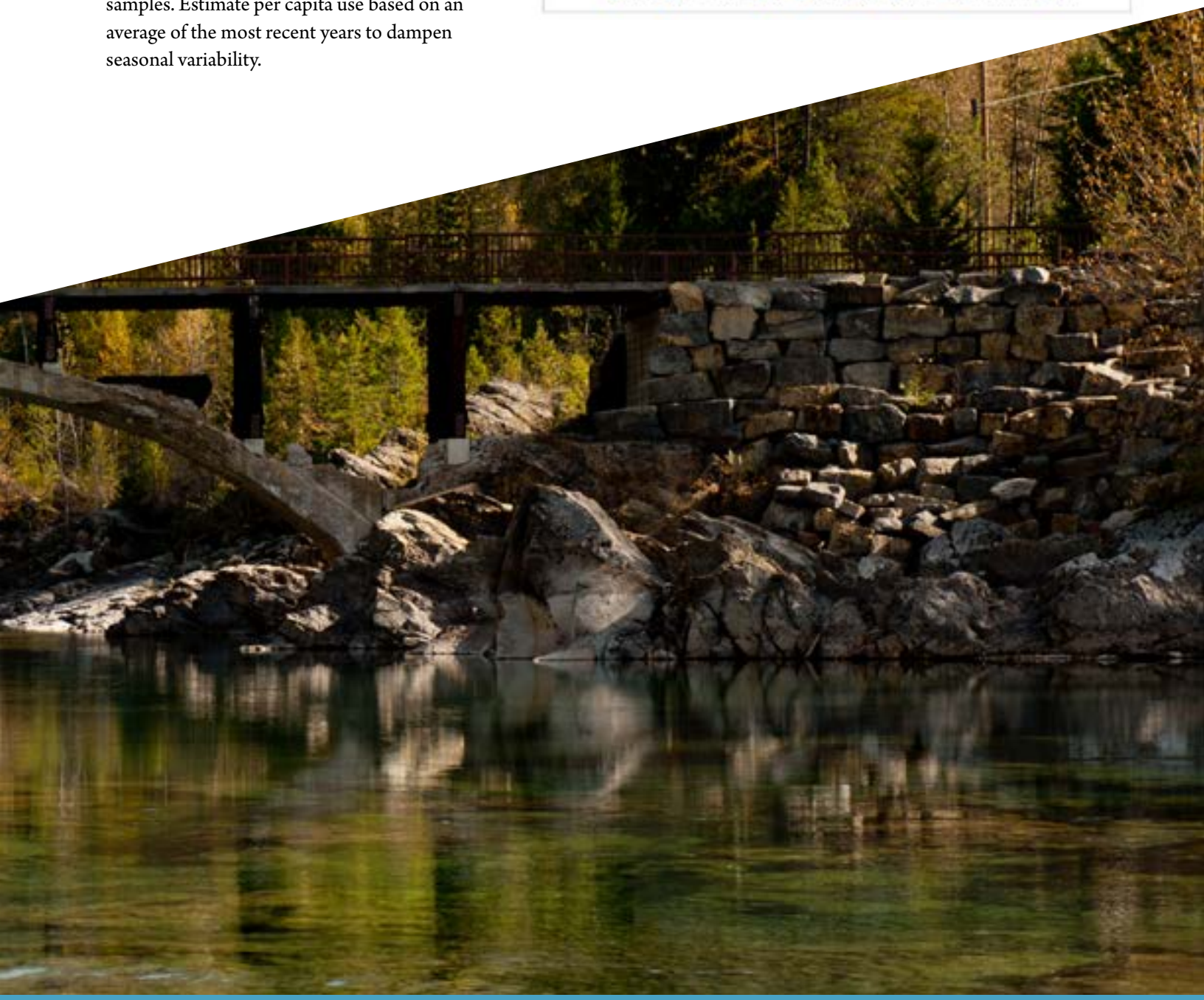
1. Calculate average annual demand, average monthly demands, and maximum day demand.
   - Ideally, calculate these demands based on a minimum of three years of data, to dampen the impacts of very dry or wet water years.
   - Break down demand over the course of the year, as shown in the monthly usage table and chart below, which enables a PWS to understand irrigation use versus indoor water use.

YEAR	MONTH	AVERAGE DAILY DEMAND (ADD)
2019	January	
2019	February	
2019	March	
2019	April	
2019	May	
2019	June	
2019	July	
2019	August	
2019	September	
2019	October	
2019	November	
2019	December	



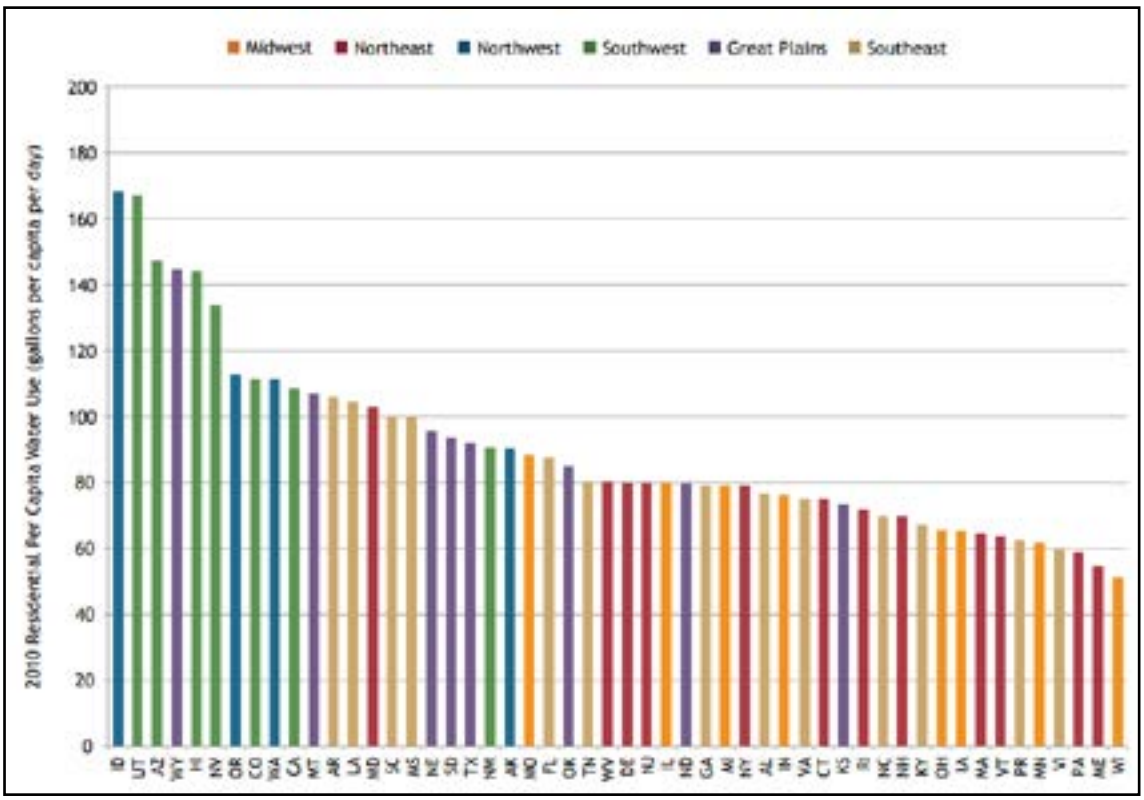
2. Estimate population and population growth rates based on available tools:
   - Local growth policy / planning documents (City, County)
   - U.S. Census data
   - Historical population growth - use past trends to project forward
3. Multiply your estimated average annual growth rate by the current population to create projections for future years. Typically, this is done for twenty- or thirty-year planning horizons.
4. Determine the annual per capita water use for each year of the demand and population data samples. Estimate per capita use based on an average of the most recent years to dampen seasonal variability.





A	B	C	D	E	F	G	H
YEAR	TOTAL PRODUCTION	AVERAGE DAILY DEMAND (ADD)	MAXIMUM MONTH (MMD)	MAXIMUM DAY (MDD)	POPULATION ESTIMATE	AVERAGE ANNUAL GPCD	PEAK GPCD
2013	From Date Collection and Historical Records					=CxF	=ExF
2014							
2015							
2016							
2017							
2018							
2019							
AVERAGE							

Montana is ranked 11th in terms of residential per capita water usage of approximately 107 gal per capita per day (gpcd) as compared to other states. Communities with little water loss (indicating distribution pipelines are in good condition) and water conservation programs and rate structures can have per capita demands of 70 to 90 gpcd. Communities with higher water loss and/or more irrigation use will trend above 120 gpcd. Western states tend to have higher evapotranspiration and generally require more irrigation that contributes to higher water use.



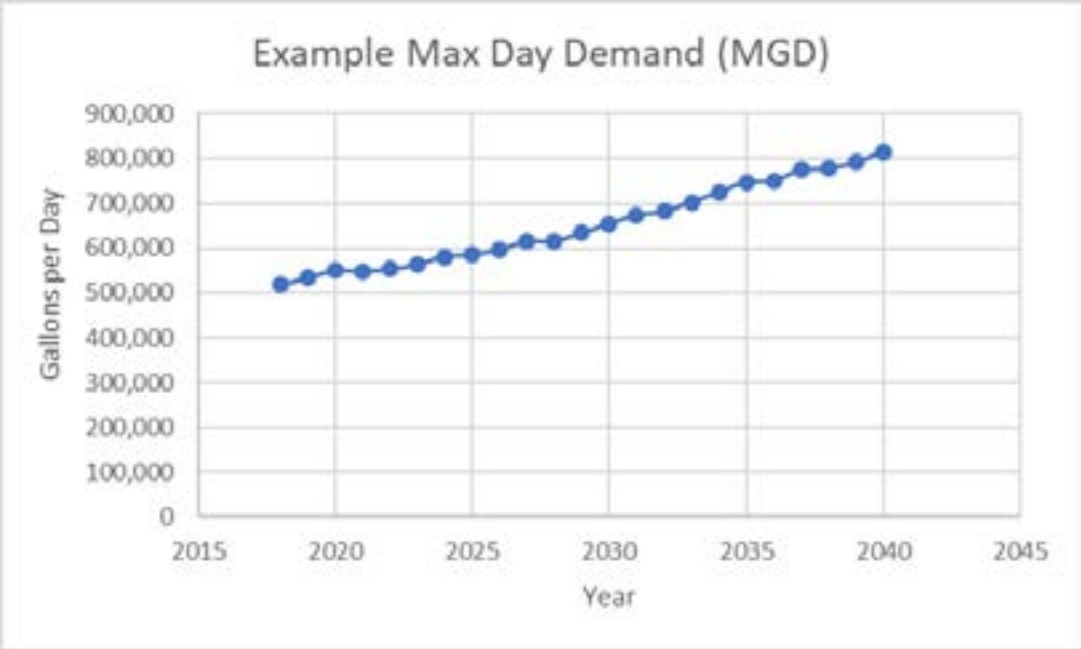
Per Capita Water Usage By State as of 2010[2]

[2]Shafer, M., D. Ojima, J. M. Antle, D. Kluck, R. A. McPherson, S. Petersen, B. Scanlon, and K. Sherman, 2014: Ch. 19: Great Plains. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 441-461. doi:10.7930/J0D798BC.

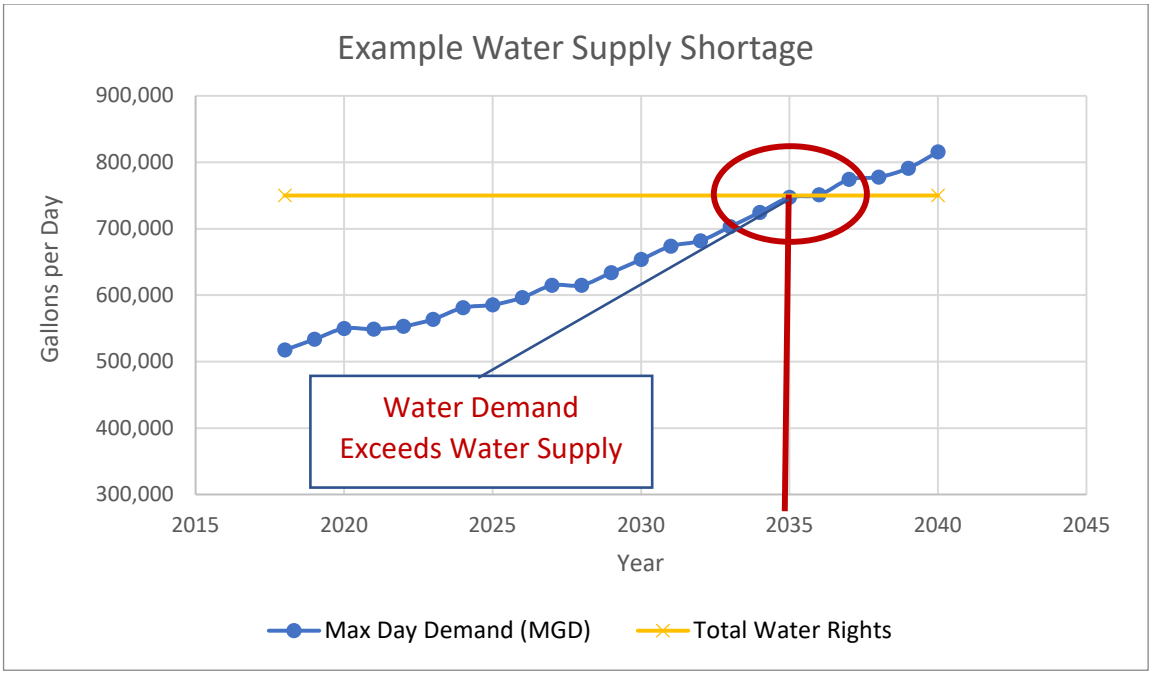
Future water demand can be projected based on the recent water demand and population data as described previously. However, any future projections should incorporate a range of potential changes in population and demand to avoid under- or overestimating future demand. This is generally referred to as scenario planning:

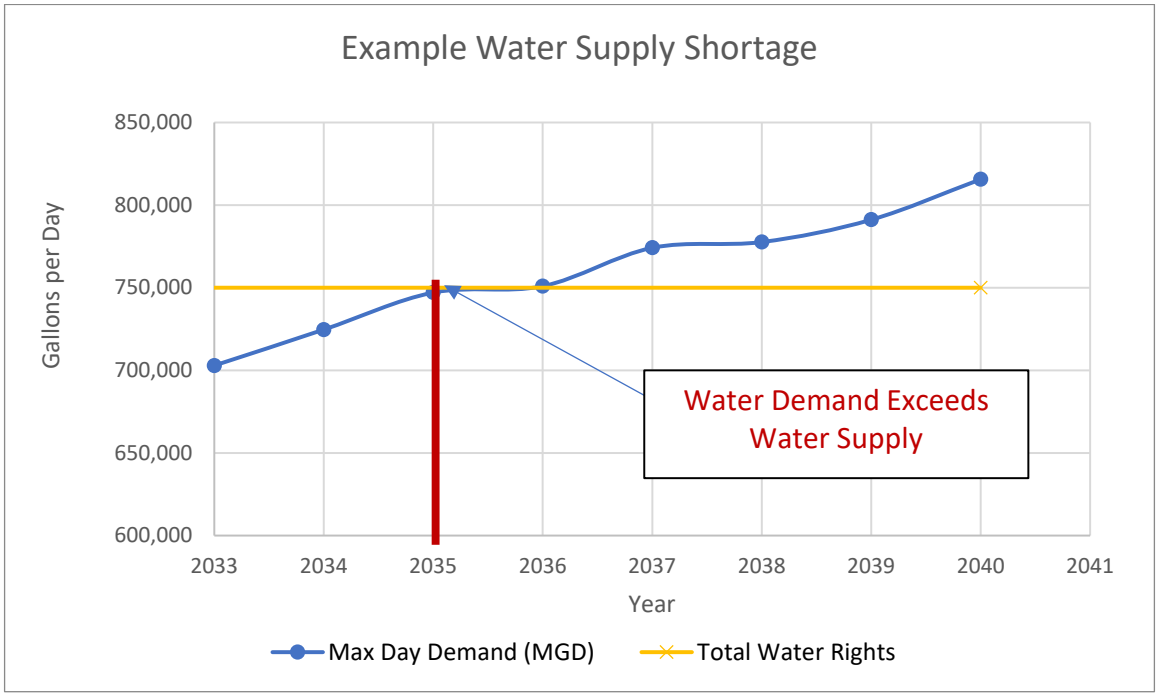
1. Multiply the projected populations in future years by the per capita water usage developed previously.
2. Develop a range of water use possibilities and growth possibilities over various planning horizons. For example:
   - Bracket current per capita water usage by +/- 20%. If your current PWS water usage is 100 gpcd, assess future demand at 80 to 120 gpcd.
   - Bracket recent population growth by +/- 1% growth. If your recent population growth has been 3%, evaluate future water demand at 2 to 4% growth.

A	B	C	D
YEAR	POPULATION ESTIMATE	MAX DAY DEMAND GPCD	MAXIMUM DAY (MDD)
2020	= 2019 population + (2019 population x Average Growth Rate)	=Average per capita water usage	=BxC
2021			
2022			
2023			
2024			
2025			
2026			



3. Compare the future demand scenarios to future water supply scenarios, with the goal of identifying the potential for a future water shortage.


Example Water Supply Shortage
900,000
800,000
700,000
600,000
500,000
400,000
300,000
Gallons per Day
2015
2020
2025
2030
2035
2040
2045
Year
Water Demand
Exceeds Water Supply
Max Day Demand (MGD)
Total Water Rights


Example Water Supply Shortage
850,000
800,000
750,000
700,000
650,000
600,000
Gallons per Day
2033
2034
2035
2036
2037
2038
2039
2040
2041
Year
Water Demand Exceeds
Water Supply
Max Day Demand (MGD)
Total Water Rights

3.3 FINDING THE RIGHT RATE DESIGN

The first and foremost objective of water rate design is to develop a rate structure that is "fair" and equitable while providing adequate revenue to meet utility financial objectives. Other important goals of rate design are to develop a rate structure that:

- Is easy to understand and administer.
- Generates a stable revenue stream over time and changing demand conditions.
- Charges customers rates that are commensurate with the level of service provided.
- Is designed to support the short and long-term objectives of the utility.

There may be other, more nuanced goals for rate structures, such as supporting economic development, providing rate relief for fixed income users, supporting asset management/capital renewal planning, or rewarding water conservation.

Current rate design should be reviewed periodically to determine whether the structure in place is appropriate for the PWS's needs. The similarity or dissimilarity of water use and/or wastewater discharge patterns of the user classes should be evaluated. If there is no clear reason to charge one user differently than another, then a simple rate structure that applies across all classes is appropriate. However, if there are substantial differences in the level of effort and/or cost to provide service to different user classes, then an evaluation of a multi-level rate structure is likely warranted.

Rate Design Considerations

Rate design entails as much sociology as mathematics, often requiring equal consideration of policy preferences and financial implications:

- Does the current rate structure meet its objectives?
- If conservation is a priority, does the structure send a price signal to motivate customers to reduce water use?
- Does the structure provide adequate revenue stability, even under conditions of reduced water demand?
- Is it easy to administer and is it perceived as fair?

If the cost of service has been assessed and shows significant disparities between cost percent and revenue percent for some user classes, then rate design options should be explored. Before making changes, however, all objectives should be revisited to ensure that concepts such as lifeline (minimum) rates, conservation, potential economic incentives, responsible annual reinvestment in the utilities, etc., are considered. If the current rate structure is considered fair and equitable and supports both near-term and long-term objectives, slight modifications within the existing structure are likely all that is needed.

Water systems vary with respect to charge for water supply and delivery services. Most systems use a combination of fixed and volumetric charges, with very few systems charging only a fixed rate or only a volumetric rate. The most common rate structure for very small systems is a flat fee, where each account is charged a fixed monthly fee, regardless of the amount of water used. Many systems utilize a combination of a flat fee and a volumetric rate structure. The most common examples of volumetric rates are listed below.

- **Declining Block**: A rate structure in which the unit price of each succeeding block of usage is charged at a smaller unit rate than the previous block(s). This approach is losing popularity for several reasons.
- **Constant Block**: A structure in which the unit price is consistent, regardless of how much water is used. This is a popular

approach and can be used to establish separate volumetric rates for each user class. Class-specific rate adjustments can then be implemented to address equitability.

- **Inclining Block**: A rate structure in which the unit price of each succeeding block of usage is charged at a higher unit rate than the previous block(s). This approach is widely used by systems to promote responsible water use and delay the need for investment in future water supply and treatment expansion.

Most larger systems have moved away from flat and declining block structures, with a noted increase in the use of constant block and inclining block rate structures. This is due largely to pressures related to source water availability, conservation initiatives, and an overall effort to minimize required capital investment in capacity related infrastructure. In addition, the declining block structure does not promote efficient water use, and funding agencies do not view declining block structures favorably when evaluating funding packages for infrastructure.

Inclining Block Rate Structures

Sometimes referred to as inverted or increasing block, an inclining block rate structure is designed such that the cost per unit of water increases with consumption. The objective of such a rate structure is to discourage unnecessary water use by increasing the cost of water that is deemed above and beyond "essential use." It is often associated with water conservation strategies, as it is an incentive to reduce overall PWS water use without substantially reducing revenue.

The objective of an inclining block rate design is to generate revenue that reflects the cost of increasing the supply and collect adequate revenue from water users who create the need to expand supply. A properly designed inclining block structure will not necessarily increase all customer bills. For those users whose usage is average for the user class and who responsibly irrigate, the cost of water should remain approximately the same or even decrease.

In contrast, users whose irrigation, or non-essential water use, contributes to the community's maximum water demand will incur higher charges to help pay for the cost of meeting maximum demand, which most often due to irrigation. If the user continues to heavily irrigate, the PWS revenue increases to enable the utility to pay for the increased wear and tear on the system, higher pumping costs, and future infrastructure expansion and replacement costs. If the user responds to the pricing signal and reduces their water use, then the PWS will incur less operational and infrastructure expenses because the overall maximum water demand will be reduced.

There are many factors to account for when considering an inclining block structure to promote conservation, including:

1. Financial impact on specific users or user classes;
2. The effects of conservation rates on utility revenues; and
3. The actual effectiveness in reducing water demand.

As a general rule, American Water Works Association (AWWA) has indicated that for a 10 percent increase in the water rate, a decreased residential total (indoor and outdoor) water use of one to three percent can be expected (AWWA, 2000).

Rate Structure Changes

Whether considering a change to the rate structure based on conservation goals or for other reasons, there are several issues that a PWS should consider:

- Educate the public and governing body on the purpose of conservation rates, how they will be applied, how they will affect billing, etc.
- Identify non-economic goals to consider throughout the rate design process and to convey to the public / elected officials in conjunction with rate recommendations (e.g. resource conservation, growth management, etc.).
- Understand the patterns of use and associated costs of service for each user class. It is important to be aware of these to avoid setting rates that could affect the ability of users to afford water service.
- Identify and understand the future costs associated with obtaining additional water supply and treatment capacity.
- Identify if there are alternative water sources (e.g. private wells, recycled wastewater for irrigation, etc.) that can significantly impact water revenue.
- Evaluate existing metering and billing practices. It is most effective to bill based on actual use rather than estimated use, and monthly billing practices will deliver the price signal more quickly than quarterly or semi-annual billing.
- Consider the formation of a rate stabilization fund to assist in the implementation stage of a new structure, in the event revenues are reduced.

Irrigation Rates

Many Montana water systems do not charge rates for outdoor watering that are appropriate for the cost associated with providing that water. Implementing responsible watering practices is largely a public relations initiative. To assist with this initiative, the Montana State University Extension Service has developed recommendations to encourage responsible outdoor water use and provide educational materials. The primary recommendations provided are:

- Avoid watering in wet or windy conditions;
- Utilize drip or soaker hoses, which can reduce evaporation by approximately 60 percent;
- Water in the early morning or early evening, when evaporative losses are lowest;
- Apply water slowly to avoid runoff and encourage deep root growth;
- Do not overwater. Established lawns need approximately one (1) to two (2) inches of water every three (3) to five (5) days; and
- Consider the use of timers, rain barrels, xeriscaping, and rain gardens.

4.0 OTHER PLANNING APPROACHES

Other planning approaches, including water efficiency, water conservation, drought management planning, and source water protection planning, can be incorporated into the IWRP process.

4.1 WATER EFFICIENCY

Water efficiency refers to reducing water loss (or non-revenue water) by implementing best management practices and improving water distribution infrastructure. Improving water efficiency can reduce water demand, but the infrastructure improvements can be costly. Examples of water efficiency activities and best management practices are summarized in the table below.

WATER EFFICIENCY ACTIVITIES AND BEST MANAGEMENT PRACTICES
• Improve metering and data collection to better estimate water loss
• Install Automatic Meter Reading (AMR) to enable faster identification of leaks
• Install submeters for large apartment or condominium complexes to enable demand-based water rate structures
• Routinely test meters and replace as needed
• Identify unmetered water uses and implement metering
• Collect and analyze water use data to identify water efficiency improvement opportunities
• Track water use by customer type and structure rates accordingly
• Revisit existing water rates and update periodically
• Institute tiered rate structures to reward water conservation
• Provide incentives for water use efficiency improvements (e.g., rebate programs for more efficient sprinkler systems)
• Obtain and routinely update a water audit to track water loss
• Implement a routine leak detection and repair program
• Replace known leaking or old water mains
• Educate ratepayers on the benefits of water efficient plumbing fixtures and appliances and drought tolerant landscaping (xeriscaping) using workshops or newspaper flyers
• Update building codes for water efficiency (require water-efficient fixtures in new construction)
• Implement irrigation efficiency on PWS owned properties (e.g., Smart Irrigation Controller, high efficiency sprinkler heads, drip systems)

Water Audit

PWS water losses are typically attributably to pipeline leaks, billing or metering inaccuracies, data handling errors, or unauthorized consumption/illicit connections. A water audit is an accounting process used to identify non-revenue water. Non-revenue water is the difference between treated water and total water metered that is billed.

Water audits provide a comprehensive assessment of a facility's water use and can identify inefficiencies within a water system. Water systems are encouraged to perform a water audit on a regular basis to improve system efficiencies.

Water audits at their most basic entail comparison of historical treated water quantities to billed / metered water quantities.

Companies exist that specialize in conducting water audits, but AWWA offers free spreadsheet-based water audit software to help quantify and track water losses associated with water distribution systems https://www.awwa.org/Resources-Tools/Resources/Water-Loss-Control.

4.2 WATER CONSERVATION PLANNING

Water conservation encompasses specific strategies, policies, and regulations implemented to efficiently manage water resources to ensure sustainable water supplies for current and future demand.

Water conservation can benefit customers by reducing future increases in water and wastewater rates.[3] When water use declines, costs to the PWS can be reduced because infrastructure, operating and water rights costs are reduced, and these savings can be reflected in future rate structure design.

Water conservation strategies typically target the following categories:

- **Water system and utility** - implement conservation program, conservation rate structure, water loss control, water waste ordinance, outdoor irrigation strategy, and public information and education programs.
- **Commercial and industrial** - examples include outdoor irrigation efficiency, pool maintenance and leak reduction, reduction of water-cooled air conditioning, and landscape watering restrictions.
- **Outdoor irrigation** - strategies include irrigation system improvements, water efficient landscape designs, and smart irrigation controllers.
- **Indoor residential** - examples include high efficiency fixture and appliance incentives, rebates for replacement of inefficient water fixtures and appliances, rules for new construction, and water use audits.

Water conservation plans can be developed as part of the Integrated Water Resources Planning process but are not required to begin the water resources planning process.

Water conservation can help:

- Improve efficiency of existing facilities to extend service life.
- Postpone or decrease the need for capital projects necessary to increase capacity.
- Improve drought or water shortage preparedness.
- Minimize costs for new source development.
- Educate customers about the value of water.
- Improve water system reliability.
- Protect and preserve environmental resources.

4.3 DROUGHT MANAGEMENT PLANNING

Drought is a naturally occurring phenomenon that may affect any climate zone in any part of Montana at a given time.

Drought management planning consists of developing effective strategies and operations to manage water demand during drought-related water shortages. There are many easily accessible resources to guide drought management planning. The Bureau of Reclamation Drought Response Program Framework: WaterSMART Program https://www.usbr.gov/drought/docs/FY16DroughtResponseProgramFramework.pdf is an excellent guide, and breaks drought planning down into the following components.

Drought Monitoring

Monitoring drought conditions enables a PWS to recognize a drought in its early stages and accurately assess its severity over time, so that appropriate responses are triggered and implemented.

[3] Feinglas, S., Gray, C., & Mayer, P. (2013). Conservation limits rate increases for a Colorado utility. Alliance for Water Efficiency, Chicago.

Vulnerability Assessment

It is important to consider vulnerability to drought, as vulnerabilities vary based on the source of water supply, location, climate and diversity of water sources. For example, surface water supplies are generally more vulnerable to short-term drought than groundwater supplies, which usually have some buffering capacity for short-term drought impacts. Conversely, aquifers may take longer to recover from longer-term drought than surface water. Increasingly communities are assessing potential climate change impacts as part of vulnerability assessments.

Adaptation Actions

Once potential impacts from drought have been identified, communities should brainstorm, vet, and institutionalize potential ways to enhance community and ecosystem resilience to future droughts. Adaptation actions are those taken in advance of a drought that reduce potential drought-related impacts when the event occurs, and they can range from additional water source development and related infrastructure improvements to policy actions such as passing an ordinance to encourage xeriscaping. Examples of drought adaptation strategies are shown in the table below.

CATEGORY	DESCRIPTION
Policy Level Planning	• Continue to develop and advocate for policy improvements • Develop cooperative sharing agreements with local water users to implement during periods of drought, which may involve exchanges, trades or agricultural leases. • Implement a policy whereby developers of subdivisions desiring annexation must provide adequate water rights or accepted offsets. • Raw surface water irrigation systems using existing water rights for new subdivisions.
New and Existing Operation and Maintenance Activities to Improve Water Distribution Efficiency	• With the addition of new supplies, modify system operations to optimize efficiency of overall distribution system and monitor current operational practices to improve efficiency where possible. • For existing supplies, optimize Water Treatment Plant operations to increase efficiencies. • Pressure zone specifications for new development. • Routinely detect and repair leaks. Monitor and replace inaccurate meters.
Reduce Water Demand/Encourage Conservation	• Continue to promote water conservation via education, rebates and other incentives. • Pursue non-potable irrigation projects. • Develop rate structures that factor in water conservation/water shortage conditions.
Develop New or Redundant Water Supplies	• Evaluate alternatives to increase water supplies as applicable. • Analyze costs and water supply yield of alternatives.
Maximize and Protect Existing Supplies	• Evaluate operational practices to improve and optimize water supplies. • Replace or repair existing infrastructure to stop water leakage and reduce water loss. • Update and develop improved Source Water Protection Program.

Response Actions

While adaptation actions can be taken ahead of a drought, response actions are activities that can be implemented during or after a drought to address impacts. Response actions are triggered during specific stages of drought to manage limited water supply and decrease the severity of immediate impacts. Implementation of water use reduction ordinances as part of a drought stage declaration is a good example. The ordinance may limit outdoor watering and impose fines on those who ignore or do not comply with the ordinance. Example response actions are shown in the table below.

ELEMENT	STAGE 1	STAGE 2	STAGE 3	STAGE 4
	Drought Watch Customer Outreach	Drought Advisory Mandatory Restrictions	Drought Warning Ban on Lawn Watering	Drought Emergency Rationing
Outdoor Watering				
Turf grass	No restrictions	Two days / week per mandatory schedule based on customer class and address	No watering permitted.	No watering permitted
New seed and sod	Permitted with exemption signage for establishment	Permitted with exemption signage for establishment	No watering permitted	No watering permitted
New plantings	Permitted	No installations from June-August	Not permitted	Not permitted
Trees, shrubs, perennials	Water efficiently	May be watered by hand-held hose or low-volume non-spray irrigation on any day, not between 10 a.m. and 6 p.m.	Existing trees and shrubs may be watered by means of a hand-held hose or low-volume non-spray irrigation no more than once per week on scheduled day	Not permitted, or use of hand-held hose or low-volume spray may be limited to no more than one assigned day per month
Flowers, vegetables, and community gardens	No restrictions	May be watered by means of a hand-held hose or low-volume non-spray irrigation on assigned watering days, not between 10 a.m. and 6 p.m.	May be watered by means of a hand-held hose or low-volume non-spray irrigation on assigned watering days, not between 10 a.m. and 6 p.m.	No watering permitted
Athletic and playing fields	No waste of water	Irrigated per mandatory scheduling or water budget restrictions	Irrigated per mandatory scheduling or water budget restrictions	No watering permitted
Golf courses	No waste of water	Irrigated per mandatory scheduling or water budget restrictions	Trees and greens only	No watering permitted

An example ordinance regarding water use reduction includes:

Authority to restrict outdoor use of water.
The director of public works is, with the concurrence of the city manager, authorized, directed and empowered, whenever in the director's opinion the necessities of the situation demand such action, to restrict or wholly prohibit the outdoor use of the water supply of the water service utility.
Restriction of particular indoor uses.
Whenever outdoor use restrictions are in effect, business establishments which serve beverages for human consumption shall be prohibited from serving water except upon request.
Sprinkling systems; timing.
Whenever outdoor use restrictions are in effect, the director of public works may set alternative time restrictions for the use of large-scale sprinkling systems or those which are equipped with a timing device.
Notice required.
Restrictions or prohibitions imposed by the director of public works shall become effective at midnight immediately following the publication of notice thereof in any daily newspaper published in the city.
Wasting water prohibited.
Whenever outdoor use restrictions are in effect, no person shall waste water which shall include but not be limited to permitting water to escape or run to waste.
Penalties.
Any person who violates this division or the restrictions issued hereunder shall be deemed guilty of a misdemeanor and upon conviction thereof shall be fined in an amount not less than $100.00 or more than $500.00.

Operational and Administrative Framework

An operational and administrative framework identifies who is responsible for undertaking the actions necessary to implement each element of a drought management plan, including public outreach tasks. At a minimum, the framework should identify roles, responsibilities, and procedures necessary to initiate response actions. Examples of operational framework and public outreach are shown in the tables on the following page.

MEMBER NAME	ORGANIZATION	TITLE	DROUGHT TEAM FUNCTION	RESPONSIBILITIES	PHONE NUMBER	EMAIL ADDRESS
			Drought Plan Coordinator	Manage the Drought Team and the Drought Plan		
			Public Works Coordination	City Commission Drought Plan liaison. Direct oversight of PW divisions		
			Water Distribution Impacts and Response, Leader of City Water Crews	Coordinate water distribution activities and utilize crews for monitoring water use during drought		
			Water/Wastewater Infrastructure Contact	Support coordination of the Drought Plan		
			Parks and Recreation Coordinator	Manage City Parks and Recreation water usage and responses to drought stages		
			Disaster and Emergency Services Contact and Coordination	Disaster and emergency coordination and drought communications coordination		
			Water Treatment Plant Operations	Monitor and report water supply and demand information		
			Disaster and Emergency Services Contact and Coordination	Disaster and emergency coordination and drought communications coordination		
			Law Enforcement	Enforcement of violations in severe drought stages		

TARGET AUDIENCE	MESSAGING TOOLS	
	LONG TERM MITIGATION	SHORT TERM RESPONSE
Commission / Utility Departments and Divisions	• Email • Meetings	• Email • Meetings • Special Presentations
Water Customers (Single Family, Multi Family, Commercial)	• Website • Social networking • Media • Workshops	• Website • Social networking • Newspaper articles • Interviews • Public Meetings • Special Presentations
Targeted Business Owners and Institutional Users	• Website • Social networking • Media • Special Presentations • Meetings	• Website • Mailers • Meetings • Special Presentations
Large Water Users	• Direct Mailers	• Direct Mailers • Special Presentations
Commercial Business Employees	• Presentations • Meetings	• Presentation • Meetings
Schools	• Water education curriculum for teachers • Water education for teachers • Special presentations	• Special Presentations

Plan Update Process

The Bureau of Reclamation's drought management guide recommends having a clear plan for updating the drought management plan over time, to ensure that it evolves with growth projections and/or other changes in supply or demand.

Drought Rate Surcharges

Water pricing can be an effective tool to reduce demand during times of drought. Drought surcharge rates are carefully developed to maintain adequate revenue to meet system revenue requirements when water sales decline. Inclining block rates, seasonal rates, drought surcharges, or excessive use surcharges are also identified as drought mitigation tools. A tiered rate structure that charges water utility customers more for higher than basic water use can be used. For drought vulnerable utilities, more aggressive structures can be utilized. These typically involve the use of rate surcharges.

A rate surcharge is a separate charge added to existing rate structures to collect either a targeted amount of revenue or to assess an appropriate charge for particular usage characteristics outside of those covered in the basic charge for service. Surcharges are often presented separately from the existing rates and labeled for the specific purpose for which the funds will be used or the events that caused the need for the surcharge. Drought surcharges are often used on an emergency and temporary basis to pay for costs associated with purchasing emergency water supplies during a severe drought or to support drought restrictions.

Water use, such as outdoor watering, is the primary target for water use reductions via drought surcharges. Consideration is also given to usage characteristics and associated with different types of users. It is important to evaluate water use factors in a community when setting surcharge rates to understand how to best effect changes to discretionary water use.

The table below summarizes various types of surcharges.

SUMMARY OF TYPES OF DROUGHT SURCHARGES		
TYPE OF DROUGHT SURCHARGE	**DESCRIPTION**	**EXAMPLE**
General Rate Adjustment	Implement a drought surcharge on all service rates.	All volume rates increased by a specific percentage estimated to yield an acceptable level of demand reduction.
General Volumetric Surcharge	Surcharges applied based on volumetric use. Identifies cost impacts of using water during droughts.	1. Uniformly applied surcharge over all consumption blocks. 2. Surcharge applied to consumption beyond a specific level. 3. Graduated increases in surcharge as consumption increases.
Class-Based Volumetric Surcharge	Establish quantity limits based on classes of users and apply a surcharge to users exceeding the limit for that class.	Volumetric surcharge by customer class of service.
Individualized Volumetric Surcharge	Apply surcharges to users based on their water demand exceedance of a specified percentage of base period water use.	A 25% surcharge applied to any customer using greater than 80% of their average demand during base period.
Targeted Volumetric Surcharge	Target certain classes that have more discretionary use for greater surcharges than others.	Implement a high surcharge on residential outdoor usage and a lower surcharge to hospitals or public schools.

Drought management must include a means of monitoring current drought conditions and utilizing the conditions to develop an overall drought stage assessment. The primary goal of a Drought Monitoring Plan is to recognize a drought in its early stages and accurately assess its severity over time, so that appropriate responses are triggered and successfully implemented.

Having a transparent, quantifiable, and scientific basis for drought declaration is critical for timely decision-making, effective communication with officials, and managing expectations of the public. The Drought Monitoring Plan must enable the PWS to react quickly, implement appropriate restrictions early, and make allowances for different types of uses and needs of different water users.

4.4 SOURCE WATER PROTECTION PLANNING

Source water protection planning consists of developing strategies to protect drinking water supplies from contamination. Proper delineation and assessment methods to identify threats to drinking water supplies will provide information needed to protect sources of water.

Potential uses of water resources in a watershed need to be considered in the source water protection program. Potential uses may include the following:

- Drinking water supply
- Recreation
- Logging
- Wildlife habitat
- Development
- Agriculture
- Industrial
- Power generation
- Wastewater treatment and disposal

It is important to organize a watershed planning team consisting of representatives from various interest groups to assist in the development of the source water protection plan.

Assessment includes identifying businesses, activities, or land uses within a source water protection area to determine the potential for contamination from these sources. Steps to complete a source water assessment consist of the following:

- Identify where water used for public water supplies comes from and the surrounding area
- Conduct an inventory of potential sources of contamination
- Assess the susceptibility of the source water area becoming contaminated

A Source Water Delineation and Assessment Report (SWDAR) has been completed for every PWS in Montana and are available on MT DEQ's website (http://svc.mt.gov/deq/dst/app/swp#/app/swp). Many SWDARs were completed in the early 2000s and can provide a good starting point for assessing current potential contaminants.

An example flowchart summarizing the procedures for developing a source water protection program is shown on the following page.

Some examples of management approaches to protect water sources include the following:

- Regulations, bylaws, ordinances
- Enforcement actions
- Land acquisitions
- Monitoring
- Emergency response plans
- Herbicide-pesticide application restrictions
- Stormwater management
- Road-salting restrictions
- Public education
- Recreation access restrictions
- Agricultural Best Management Practices (BMPs)

Completed source water protection plans should be submitted to MT DEQ for review and certification every five years. Certified plans are helpful to secure funding to help implement the plan. Successful source water protection planning can provide information to improve raw water quality and lead to identification of water quality issues and mitigation strategies. Technical assistance for source water protection planning and implementation is available through Montana Rural Water Systems. More information can be found in Montana Source Water Protection Technical Guidance Manual (MBMG 1998) which may be available by contacting Montana Rural Water Systems. (http://mrws.org/)

5.0 CONCLUSION

Integrated water resource planning (IWRP) and management is a continuous process which can be used at the local county, or regional level to support the water planning and management process to meet the needs of a defined area. The planning process evaluates supply and demand issues while considering utility, community, and environmental concerns to address future needs. IWRP should incorporate a decision-making process with participation from affected stakeholders. Benefits of public involvement throughout the planning process include:

- Understanding and addressing the concerns of the public.
- Increasing public access to accurate information and communicating water quality and water quantity issues more effectively.
- Increasing public support and improving the image and reputation of the PWS.

Specific parts of the IWRP process can be used or a detailed comprehensive plan can be developed to assist with water planning for a PWS depending on available resources and the level of detail desired. The main components of the IWRP process include the following sections.

- **Water Supply** - Developing water supply assessment and monitoring strategies to provide guidance for future water resource management. A combination of water supply and water rights evaluations along with a vulnerability assessment is recommended as the first steps.
- **Water Demand** - Understanding the water demands of the PWS to define water use patterns by processing historical water demand data will assist with forecasting future water demand and the need for new water supplies or infrastructure.
- **Other Planning Approaches** - Other planning strategies including water use efficiency / water conservation planning, drought planning, and source water protection planning, may also be help for the PWS plan for future scenarios.

6.0 REFERENCES

6.1 INTEGRATED WATER RESOURCES PLANNING RESOURCE

1. "Water Resources Planning" AWWA Manual M50 (2017, 3rd Edition).
   https://store.awwa.org/store/productdetail.aspx?productid=63491393

   AWWA's Integrated Water Resource Planning resource for purchase provides an overview of water resources planning and a summary of a general water resources planning methodology.

   An excellent overview of the document can be found here:
   https://www.awwa.org/Portals/0/files/publications/documents/M50-3LookInside.pdf
   This resource provides an overview of water resources planning, including emphasis on policies, legal issues (water rights), and descriptions of various water resources (including demand management).

   This resource also provides a good explanation of water demand forecasting models, a background on water quality issues, source water protection recommendations, and how to assess water supplies. The final chapter provides recommendations on developing an Integrated Water Management Plan.

2. Palmer, Richard N., and Kathryn V. Lundberg. "Integrated Water Resources Planning."
   https://www.isws.illinois.edu/iswsdocs/wsp/IWRP_Palmer_Lundberg.pdf

   This free document served as the basis for AWWA's first Integrated Water Resource Planning resource and provides a good overview of the IWRP process and a summary of a general water resources planning methodology. Sections include:
   - Advantages of IWRP
   - History and Characteristics of Water Resources Planning
   - Public Involvement
   - Water Demand Forecasting
   - Water Supply Reliability Evaluation
   - Source Strategies
   - Developing Resource Portfolios
   - Drought Contingency Planning
   - Emergency Planning and Vulnerability Assessment
   - Modeling the IWRP Process

6.2 WATER DEMAND FORECASTING REFERENCES

1. Water Research Foundation Demand Forecasting Weekly to Long-Term Forecasts are Essential for Operations and Planning. Fact Sheet April 2017. http://www.waterrf.org/knowledge/water-efficiency/FactSheets/water-efficiency_demand-forecasting_factSheet.pdf
2. US EPA Water Conservation Plan Guidelines: Part 3 Basic Guidelines April 1998. https://19january2017snapshot.epa.gov/www3/watersense/docs/part3_508.pdf

6.3 VULNERABILITY ASSESSMENT RESOURCES

1. Water Demand Vulnerability Assessment Checklist https://water.ca.gov/LegacyFiles/climatechange/docs/Appendix%20B%20Vulnerability%20Assessment%20Checklist-Final.pdf
2. US Environmental Protection Agency web-based software application tool titled Climate Resilience Evaluation and Awareness Tool (CREAT) https://www.epa.gov/crwu/creat-risk-assessment-application-water-utilities

6.4 DROUGHT MANAGEMENT RESOURCES

1. Managing Water in the West. Drought Response Program Framework: WaterSMART Program. U.S. Department of the Interior, Bureau of Reclamation, May 2015 https://www.usbr.gov/watersmart/
2. Alliance for Water Efficiency Resource Library Drought and Drought Response http://www.allianceforwaterefficiency.org/Drought_Introduction.aspx
3. Bozeman Drought Management Plan https://www.bozeman.net/government/water-conservation/drought-management
4. Colorado Water Conservation Board Local Drought Planning http://cwcb.state.co.us/water-management/drought/Pages/LocalDroughtPlanning.aspx

6.5 WATER CONSERVATION RESOURCES

1. US EPA Water Conservation Plan Guidelines April 1998. https://19january2017snapshot.epa.gov/www3/watersense/pubs/guide.html
2. Bozeman Water Conservation. https://www.bozeman.net/government/water-conservation

6.0 REFERENCES Continued

6.6 WATER USE EFFICIENCY RESOURCES

1. WaterWise, Colorado. "Guidebook of Best Practices for Municipal Water Conservation in Colorado." Denver, CO: Colorado WaterWise (2010). http://coloradowaterwise.org/Resources/Documents/BP%20Project/CWW%20Best%20Practices%20Guide%20-%20FINAL.pdf
2. Colorado Water Conservation Board. "Municipal Water Efficiency Plan Guidance Document." July 2012. https://dnrweblink.state.co.us/cwcbsearch/ElectronicFile.aspx?docid=208193&dbid=0

6.7 WATER AUDIT RESOURCES

1. AWWA Water Loss Control Resource Community https://www.awwa.org/resources-tools/water-knowledge/water-loss-control.aspx
2. Alliance for Water Efficiency Water Audit Process Introduction. http://www.allianceforwaterefficiency.org/Water_Audit_Process_Introduction.aspx

6.8 SOURCE WATER PROTECTION PLANNING RESOURCES

1. Montana Source Water Protection Technical Guidance Manual (MBMG 1998)
2. Montana Rural Water Systems Source Water Protection Planning Technical Assistance - www.mrws.org

6.9 CURRENT CONDITIONS MONITORING RESOURCES

Precipitation

National Weather Service Climate Prediction Center
http://www.cpc.ncep.noaa.gov/

Montana Snow Survey and Water Supply Forecasting Program
https://www.nrcs.usda.gov/wps/portal/nrcs/mt/snow/

NRCS Snow and Water Supply
https://mslservices.mt.gov/Geographic_Information/Maps/watersupply/

Snowpack

NRCS Snow and Water Supply
https://mslservices.mt.gov/Geographic_Information/Maps/watersupply/

Streamflow

NRCS Snow and Water Supply
https://mslservices.mt.gov/Geographic_Information/Maps/watersupply/

USGS Current Water Data for Montana
https://waterdata.usgs.gov/mt/nwis/rt

USGS MT Streamflow Table
https://waterdata.usgs.gov/mt/nwis/current?type=flow

Reservoir Levels

USGS MT Lake and Reservoir Table
https://waterdata.usgs.gov/mt/nwis/current?type=lake

MT State Library Reservoir Levels
https://mslservices.mt.gov/geographic_information/maps/watersupply/statewide/StatewideReservoirLevels.aspx

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