Evaluation of Montana's Water Resources

Using a Water Budget Approach

Montana Association of REALTORS®

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This report examines the water resources situation in selected closed basins in Montana using basic hydrologic principles that are predicated on a scientific methodology known as the Water Budget.

Introduction

The status of water resources in the United States varies dramatically for a variety of reasons that are predicated largely on climate, geology, and population. The availability of water is a major factor affecting the density and distribution of population, which, in turn, impacts the nature of economic growth over a variety of sectors including agriculture, power, industrial, commercial, housing, and recreation.

Montana has been highly dependent upon on its water resources for more than one and one-half centuries. This resource was instrumental in serving Montana's initial economy, which thrived on resource extraction and agriculture. As Montana's economy has evolved, its use of water has been expanded to include recreation, power, commercial, and housing growth. In effect, these new opportunities have made for a more prosperous Montana.

We as Montanans have a relatively abundant supply of surface water and groundwater. From a volume perspective, most water use in Montana is appropriated from surface water. More recently, there has been an increasing demand for groundwater for a variety of purposes including agriculture, municipal, and private water supplies. Although the amount of groundwater use is presently very small in comparison with available volume, some are concerned that a growing demand on groundwater supply may cause adverse impacts to others who depend upon surface water.

Montana's Constitution and Water Use Act both contemplate that water is and should be available for the use and development of the people of Montana. Specifically, it is express state policy that "All surface, underground, flood, and atmospheric waters within the boundaries of the state are the property of the state for the use of its people and are subject to appropriation for beneficial uses as provided by law." Mont. Const. Art. IX, Sec. 3(3); see also, Mont. Code Ann. §85-2-101(1). Furthermore, in Mont. Code Ann. §85-1-101, the Montana Legislature has declared the following policies regarding water use:

(1) The general welfare of the people of Montana, in view of the state's population growth and expanding economy, requires that water resources of the state be put to optimum beneficial use and not wasted.

(2) The public policy of the state is to promote the conservation, development, and beneficial use of the state's water resources to secure maximum economic and social prosperity for its citizens.

(3) The state, in the exercise of its sovereign power, acting through the department of natural resources and conservation, shall coordinate the development and use of the water resources of the state so as to effect full utilization, conservation, and protection of its water resources.

In order to facilitate such use, the Montana Water Use Act contemplates that Montanans will have a procedure to obtain new appropriation rights in the wider context of the prior appropriation system.

Water Rights

Montana is a prior appropriation state as are most of the western states. Under the prior appropriation doctrine, one's priority, or ability to appropriate water during low flow periods, is based on the date that the water user first appropriated water and applied that water to beneficial use. One of the key phrases of the prior appropriation doctrine is "first in time, first in right." The prior appropriation doctrine protects senior water users by granting them the ability to "make call" on junior users, meaning that during periods of lower flows, water users with earlier priority dates can require water users with later priority dates to cease use, thereby insuring that water is available for more senior users.

As applied in the Montana Water Use Act, Mont. Code Ann. §85-2-101, et. seq., the prior appropriation doctrine prohibits any later appropriation from adversely impacting senior water users such that senior water users cannot reasonably exercise their water rights. However, prior appropriation does not grant senior water users the right to prevent any changes in water conditions. See, Mont. Code Ann. §85-2-401(1). Moreover, the Montana Water Use Act provides an exemption to the beneficial use permit process for small domestic and stock water wells that pump less than 35 gallons per minute and utilize less than 10 acre feet of water annually. See, Mont. Code Ann. §85-2-306(3)(a).

REALTOR® Legislative Position Statement on Water

The 2008 MAR Political Affairs Committee and MAR staff examine a multitude of issues that concern the industry and property owners and make policy recommendations to the MAR Board of Directors. MAR has adopted the following position statements relating to water:

Water Rights

REALTORS® believe it is important for the State of Montana to complete the water rights adjudication process in a timely manner in order to protect existing water rights and assure water availability for future needs, including domestic use. Failure to complete adjudication makes Montana vulnerable to downstream states who take water for their needs while impacting recreational opportunities and other water-related activities in Montana. When adjudication is complicated by the water compacting process, we strongly support allowing the State Reserve Water Rights Compact Commission to enter into an Interim Agreement with the parties involved. We support the present system of appropriation of water rights through state water law.

REALTORS® also believe that while the proper review of new appropriations of water and changes in existing appropriations is necessary to protect existing senior users, such review should not be used in such a manner as to maintain zero change in stream conditions or as a method of regulating land use and development. REALTORS® fully support the constitutional right of all Montanans to appropriate waters of the state for beneficial uses as provided by law.

Closed Basins

Closed basins are watersheds in Montana that have been closed to further surface water appropriations pending the adjudication of existing surface water claims. An excellent overview of closed basins is provided by the Montana Bureau of Mines and Geology ("MBMG") (LaFave, 2008). Statutory basin closures were enacted to close selected basins to new surface water appropriations until adjudication could be completed. In short, the closed basin statutes were meant to impose a moratorium on surface water claims until the Montana Water Court could sort out the existing surface water claims. However, in enacting the closed basin statutes, the legislature also made provisions for specific exemptions to allow limited continued new appropriations, even while adjudication was pending. These specific exemptions include exemptions for new groundwater development.

REALTORS® support the development and implementation of clear and consistent rules for the permitting of new appropriations of water and changes in existing appropriations, applied equally to applicants and objectors. The laws of Montana have established independent systems for the regulation of water quality and water rights, and REALTORS® believe that such a system should be maintained.

Water Quality

REALTORS® understand that clean water is a key element of a healthy environment. Montana's water nondegradation law is one of the toughest in the nation. We support the Montana Water Quality Act and continued state primacy in establishing standards and criteria aimed at protecting our health and safety as long as they are based on scientific evidence.

Exempt Wells

REALTORS® believe that exempt wells must be preserved. The use of exempt wells to provide water for residential purposes is, in part, a response to the difficulties and costs associated with the process of applying for new beneficial use permits and transferring existing water rights. REALTORS® support establishing a more efficient water rights permitting process and implementation of that process in a clear and consistent matter.

More recently, concerns have surfaced regarding groundwater-surface water interaction in closed basins and whether new groundwater appropriations in closed basins will adversely affect surface water appropriators. That concern has led, in turn, to the enactment of House Bill 831 by the 2007 Legislature. The main purpose of this bill was to require some form of mitigation in the event that a proposed groundwater appropriation would adversely impact surface water users.

Surface Water and Groundwater Interaction

Scientists have recognized for well over a half a century that surface water and groundwater systems are connected or integrated. In other words, use of one may affect the other. For instance, pumping groundwater may intercept groundwater that would otherwise have eventually entered streams. Similarly, changes in the way that surface water is used can also affect the rate and distribution of recharge to groundwater systems. For example, surface water diversions for agricultural use can reduce recharge that may occur from a stream, but, at the same time, increase recharge at other locations from ditch seepage and land application of irrigation water.

Population Growth and Water Demands

It is important to understand the relative magnitude of water demand that occurs from population growth. In some instances, irrigated land has been replaced with residential development as cities grow and subdivisions develop over time. The net significance of this can be twofold. On one side of the coin, there will be increased water requirements to support this growth. Yet, on the other side, land that had been irrigated for agricultural purposes theretofore is no longer being irrigated, decreasing net water demands. Another possibility is that growth may occur over lands that had not been historically irrigated. All these create a level of complexity in determining just how the hydrologic system will respond to these changing land use practices and changing water demands.

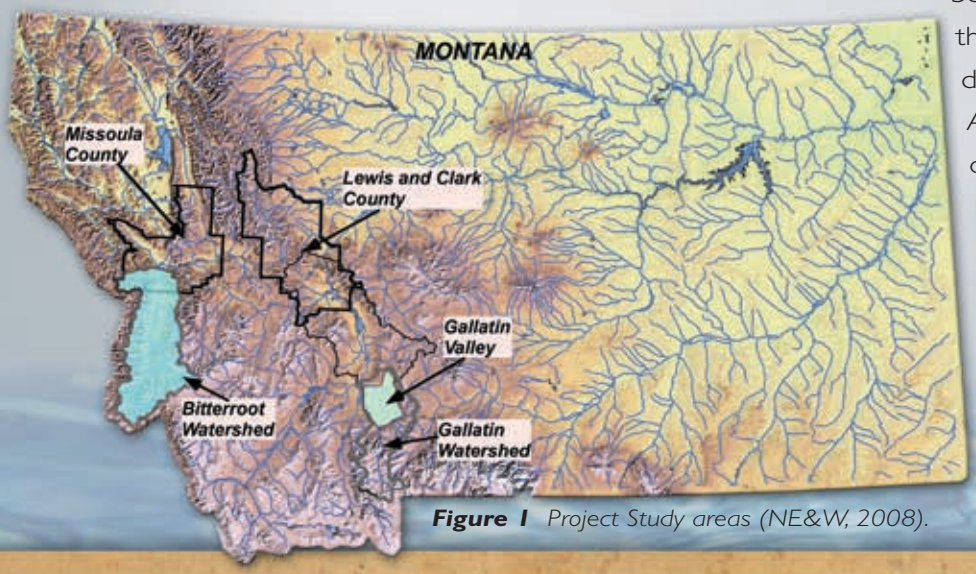

Figure 1 *Project Study areas (NE&W, 2008).*

Some believe that Montana is presently suffering the same fate as other western states such as Colorado, Arizona, Texas, and New Mexico, which are all grappling with groundwater development and shortages. However, it is important to recognize that conditions from state to state vary drastically. For instance, the status of hydrologic, hydrogeologic, and other factors, including economics and population, is not the same in Montana as they are in Colorado, Arizona, Texas, or New Mexico. Groundwater demands in Montana are much lower when compared to other states (Hutson et al., 2000):

• Montana	188 million gallons per day (mgd)	
• Colorado	2,320 mgd	12 times the Montana demand
• Arizona	3,420 mgd	18 times the Montana demand
• New Mexico	1,540 mgd	8 times the Montana demand

Additionally, water supplies are much different in these states as a result of precipitation over a larger land area. The total amount of annual precipitation is greater in Montana when compared to the other states. For example, according to the US Geological Survey, Montana's total precipitation is 17% more than Colorado and 30% more than New Mexico (Carr et al., 2000).

When it comes to population growth and water demands, several questions remain to be answered:

- How much has net water use changed with development?
- Has there been a net increase or decrease in water use?
- Has the development been significant enough that the impacts are evident in changing streamflows or changing groundwater levels?

These and many other questions need answers that are derived from evaluations employing basic scientific principles.

Groundwater Levels

Work by the MBMG shows that groundwater level changes are dominated by climatic factors (Patton, 2007). MBMG has not determined that declines associated with groundwater development are significant in Montana. In effect, unlike what has occurred in the Ogallala aquifer in Western Texas, there is no evidence of changes in aquifer storage over time associated with groundwater development in Montana.

In order to determine cause-and-effect changes in streamflow and groundwater levels, it is necessary to examine all underlying factors. For instance, what is the impact of climate and all uses of water from agriculture, power generation, housing, etc. This report examines the water resources situation in selected closed basins in Montana using basic hydrologic principles that are predicated on a scientific methodology known as the water budget. The areas examined are shown in Figure 1 on the previous page.

Hydrologic Cycle

Groundwater and surface water are components of a complex, dynamic system that is known as the hydrologic cycle, which is illustrated in Figure 2. Nearly all precipitation ultimately seeps into the ground, flows overland and in streams, and evaporates or is transpired into the atmosphere from plants. There are several human interventions that affect both surface water and groundwater, including dams that control streamflow, diversions of water for agricultural irrigation, and diversions for municipal or domestic use.

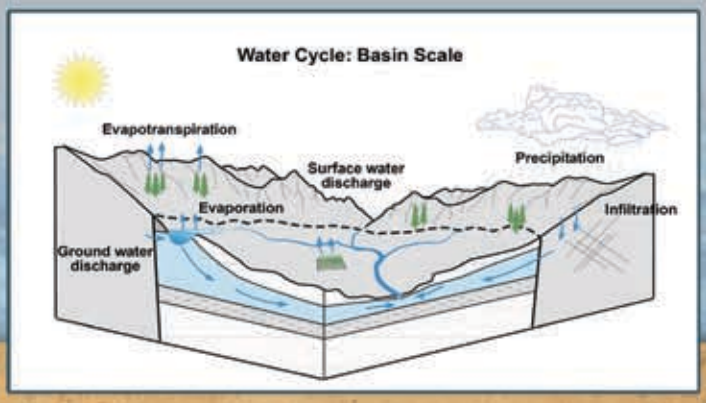

Figure 2 *Schematic representation of the hydrologic cycle in a typical Montana basin scale. Adapted from Montana Bureau of Mines & Geology (2008).*

Montana's climate is cooler and, except for Colorado, has higher annual average precipitation than the other states. Montana is a headwater state with significant mountainous regions where winter snowfall accumulates and then supplies streams and rivers. This same surface water recharges the valley aquifers. The volume of water leaving Montana as streamflow is significantly higher than other states (Carr et al., 1987).

• Montana	39,500 mgd	
• Colorado	11,600 mgd	29% of Montana's surface water outflow
• Arizona	12,700 mgd	32% of Montana's surface water outflow
• New Mexico	3,000 mgd	8% of Montana's surface water outflow

In simple terms, Montana has a large water supply, with much lower demand and exports much more water than these other states. ***In effect, Montana has more water and uses less of it when compared to these states.*** When all the relevant comparisons are made to other states, Montana's groundwater is an untapped resource.

Some parts of the country have shown significant declines in groundwater levels. For instance, the Ogallala aquifer in Western Texas has shown significant declines in groundwater levels. Most of these declines are associated with center pivot irrigation from agricultural irrigation. This has resulted in a storage decline of about 50 million AF from 1990 to 2004.

Water Budgets

One basic methodology used in quantifying water availability and water use is known as the water budget. According to the U.S. Geological Survey (Healy et al., 2007):

> Water budgets provide a means for evaluating availability and sustainability of a water supply. A water budget simply states that the rate of change in water stored in an area, such as a watershed, is balanced by the rate at which water flows into and out of the area. An understanding of water budgets and underlying hydrologic processes provides a foundation for effective water resource and environmental planning and management. Observed changes in water budgets of an area over time can be used to assess the effects of climate variability and human activities on water resources. Comparison of water budgets from different areas allows the effects of factors such as geology, soils, vegetation, and land use on the hydrologic cycle to be quantified.
>
> Human activities affect the natural hydrologic cycle in many ways. Modifications of the land to accommodate agriculture, such as installation of drainage and irrigation systems, alter infiltration, runoff, evaporation, and plant transpiration rates. Buildings, roads, and parking lots in urban areas tend to increase runoff and decrease infiltration. Dams reduce flooding in many areas. Water budgets provide a basis for assessing how a natural or human-induced change in one part of the hydrologic cycle may affect other aspects of the cycle.

In summary, water budgets are valuable for understanding the relative significance of water use transitions and other factors that may affect both surface water and groundwater supplies in Montana. A water budget is an accounting of water inputs, outputs, and storage over a fixed area or volume conducted over time. Depending upon the water budget boundaries, inputs can include precipitation and streamflow. Outputs can include streamflows, evaporation and transpiration, well pumping, and reservoir evaporation. Storage changes can result when reservoir water levels decline. Groundwater storage can change if water levels increase or decrease. In essence, a water budget is akin to a banking account where one tracks bank deposits, withdrawals, and the account balance over time.

The water budget equation is simple, *universal,* and adaptable because it relies on a few assumptions on the fundamentals of water movement and storage. A basic water budget for a watershed can be expressed as follows (Healy et al., 2007):

$$P + Q_{in} = ET + \Delta S + Q_{out}$$

where

P	is precipitation;
Q_{in}	is water flow into the watershed;
ET	is evapotranspiration (the sum of evaporation from soils, surface water bodies, and plants);
ΔS	is change in water storage; and
Q_{out}	is water flow out of the watershed.

The water budget can be applied to various scales. For example, it can be statewide or it can be at a local scale, such as the Gallatin Valley or the Bitterroot Valley. Sometimes specific data are not available, and inputs or outputs must be estimated as closely as is practical. Understanding each component is necessary in order to reliably quantify the degree of human-induced influence on the water budget.

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What Is Montana's Overall Water Budget?

A general water budget assessment for Montana was developed by the USGS (Cannon and Johnson, 2004). Montana receives an average of about 118.4 million acre feet (AF) of water in the form of precipitation each year (about 886 billion gallons). An AF is a volume measurement commonly used by agricultural irrigators. One AF is the same as one foot of water spread evenly over one acre of land, or equal to 325,800 gallons of water.

An average of 43.8 million AF (about 328 billion gallons) of water flows out of Montana each year via the Yellowstone, Missouri, Clark Fork, and Kootenai Rivers. The difference between the incoming 118.4 million AF and the out-flowing 43.8 million AF is 74.6 million AF. This difference is the water that is transferred directly to the atmospheric portion of the hydrologic cycle via evaporation and plant transpiration. Much of the plant transpiration is associated with native vegetation.

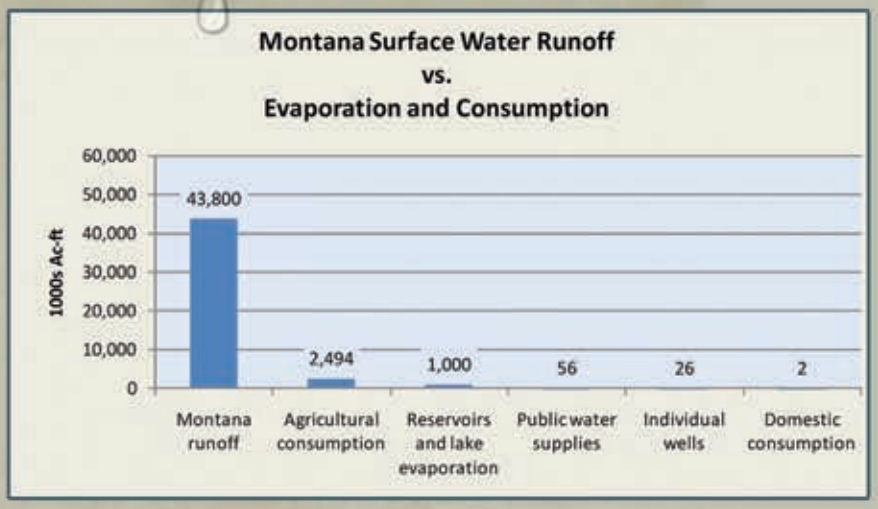

Figure 3 *Montana Surface Water Runoff compared to various annual consumption rates (note that this is for comparison purposes; some categories may overlap).*

Some Basic Terminology

Evapotranspiration: Evapotranspiration simply represents the water returned to the atmosphere via a combination of evaporation and transpiration by plant growth (see water budget equation on the previous page).

Aquifer: An aquifer is considered a hydrogeologic unit that is capable of transporting groundwater at rates sufficient to yield economically significant quantities of water to wells and springs.

Recharge: Recharge involves all the processes that add water to a saturated zone.

Phreatophyte: A phreatophyte is a deep-rooted plant that obtains water from the underlying groundwater. These plants often use large volumes of water. Two examples that are relevant to Montana are cottonwoods and willows.

Consumptive Use: Consumptive use represents the amount of withdrawn water lost to the immediate hydrologic environment through evaporation, plant transpiration, incorporation into products or crops, or consumption by humans and livestock.

According to the USGS, the total amount of water withdrawn in Montana from surface water and groundwater combined is about 12 million AF (90 billion gallons). However, a majority of the withdrawal is "recycled" as flow returning to groundwater as recharge, which eventually enters streams.

Let us consider surface water first. Again, about 118.4 million AF (about 328 billion gallons) of precipitation falls on Montana each year. Of this, about 2.7 million AF (20 billion gallons) is consumptively used by human actions. Thus, about 2.3 percent of the precipitation that falls on Montana each year is consumed.

Again, the amount of water flowing out of Montana is 43.8 million AF each year. Figure 3, on the previous page, compares the consumptive uses to the flow leaving Montana each year. These uses can be compared to some of the following categories (Cannon and Johnson, 2004):

- Agricultural consumption from crops and livestock: 2.49 million AF;
- Reservoir and lake evaporation: 1 million AF;
- Public water supplies: 0.056 million AF;
- Individual wells: 0.026 million AF; and
- Household use such as washing, drinking, etc.: 0.002 million AF.

Using these statistics, the total consumptive use from individual wells is 0.05 percent of the overall combined consumptive use from agriculture and reservoirs/lakes. Using another comparison, the total annual consumptive use from individual wells is about 0.005 percent of all surface water leaving the state of Montana each year.

If we combine all uses for municipalities, subdivisions, and individual wells in Montana, they equate to about 0.2 percent of the streamflow leaving Montana each year. Even when we combine these uses they are too small to be measurable in the streamflows of Montana.

What Is the Projected Impact of Population Growth?

Using the results shown in Figure 3 on the previous page, the actual consumption for housing and municipalities is about 0.2 percent of all the outflow of water leaving Montana each year. Population growth will require additional water supply. However, in order to put the projected increase in perspective, it is practical to use the U.S. Census Bureau's projection that Montana's population will grow another 16 percent by 2030. Using a simple ratio, it can be projected that the net relative increase in water consumption from this growth will be approximately 0.03 percent by 2030. Hence, the net overall demand strictly associated with water supply needs of municipalities, public water supplies, and individual homeowners would be about 0.23 percent of all the total water consumption in Montana in 2030. This calculation does not consider decreased consumption in other areas as irrigated agricultural property is converted into residential development.

If we combine all uses for municipalities, subdivisions and individual wells in Montana, these equate to about 0.2 percent of the streamflow leaving Montana each year.

Local Scale Water Rights

What About Water Budgets at the Local Scale?

Nicklin Earth & Water ("NE&W") conducted water budget evaluations for four different areas of Montana (NE&W, 2007 and NE&W, 2008a). The primary purpose of evaluating these different areas was to determine if observations were consistent among high growth areas. The high growth areas examined were the Gallatin Valley, Bitterroot Valley, Lewis and Clark County, and Missoula County. All of these areas show increases in groundwater development from population growth. In all of these instances, the water budgeting approach described by the USGS was employed.

The primary results of the analysis are that the local-scale results are simply a microcosm of the statewide observations. In effect, overall water use by housing and municipalities is currently very small and is projected to remain very small through at least 2030.

Gallatin Valley Water Resources

The Gallatin Valley is located at the northern end of the Gallatin watershed (see Figure 4). This valley is the center of a thriving and diversified county that has been historically agriculturally based. More recently, economic activity in the valley has become more diversified and includes agriculture, rapid commercial and residential development, an expanding state university, and a growing high-tech sector. Along with growth in these core economic sectors, the service industry also has greatly expanded. Gallatin County has seen more rapid population growth than almost any other county in Montana. Hence, concerns have developed regarding the impact of groundwater development upon available streamflows in the valley. The concerns are exacerbated by the fact that the entire Gallatin watershed is subject to the Upper Missouri River Basin Closure.

Figure 4 *Gallatin Watershed and Gallatin Valley.*

Overall water use by housing and municipalities is currently very small and is projected to remain very small through at least 2030.

The amount of precipitation controls the availability of surface water and groundwater in the Gallatin Valley, as is the typical situation throughout Montana. For instance, a relatively recent long-term drought led to a temporary decline in streamflows in the Gallatin Valley. Similarly, a few observation wells show temporal declines in water levels. Even though the cause-and-effect relationship between climate, streamflow, and groundwater level responses seems obvious, some have inferred that the best explanation of these changes is the groundwater development associated with subdivision growth.

One main objective of the case study for the Gallatin Valley was to provide more definitive answers to potential cause-and-effect factors by conducting a detailed analysis of the available climatic, streamflow, and groundwater level data. This included the use of water budgeting methods to determine the relative significance of the growth in groundwater use from housing and assess its relative effects, if any, on streamflows in the Gallatin Valley.

The water budget in the valley can be divided into the following general categories (see Figure 5):

- Precipitation falling on the valley;
- Streamflow entering the valley;
- Evapotranspiration throughout the valley; and
- Streamflow leaving the valley.

The amount of precipitation that falls is critical to the available water budget in two ways: precipitation that falls directly within the valley and precipitation outside the valley. In particular, the snowmelt from snowpack is a key factor affecting the water budget of Gallatin Valley.

Precipitation evaporates, runs directly off the land into the streams, or seeps into the underlying geologic strata as recharge. A substantial portion of the recharge that ends up as groundwater then ultimately flows into a stream as base flow. This base flow keeps many streams flowing throughout the year. If a long period of persistent drought occurs, recharge rates are reduced, and base flow decreases accordingly. On the other hand, during periods of above-average precipitation, recharge rates increase, leading to increases in base flow. Other factors that affect base flow in the valley include irrigation diversions. However, the loss of the irrigation water from ditch seepage and the increased recharge that may occur over irrigated land can also improve base flow conditions. It does get very complicated, as the same base flow may be diverted again.

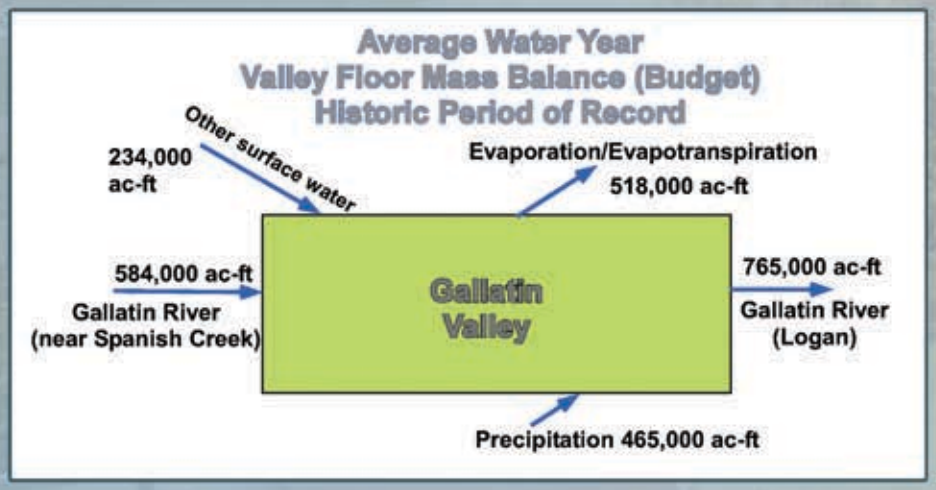

Figure 5 *General Water Budget for average year in Gallatin Valley.*

What Is the Influence of Snowpack on the Water Budget in the Gallatin Valley?

The Natural Resources Conservation Service (NRCS) installs, operates, and maintains an extensive automated system designed to collect snowpack and related climatic data in the western United States and Alaska. This system, called SNOTEL (for SNOpack TELemtry), operates over 660 remote sites in mountain snowpack zones. Congress mandated NRCS (then the Soil Conservation Service) in the mid-1930s "to measure snow pack in the mountains of the West and forecast the water supply" (NRCS, 2003).

Snow water equivalent is the measure that defines the depth of water that is produced by a given snowpack. It is measured at a SNOTEL station by a pressure sensor that quantifies the weight of snowpack that lies on a snow pillow.

The streamflow that enters the Gallatin Valley each year is dominated by the amount of snowpack present in the entire Gallatin Valley watershed. Figure 6 on the next page provides a cumulative departure-from-average plot for the Carrot Basin SNOTEL station. It defines the accumulation of either above-average or below-average snowpack over the period of record. If there is a long period of above-average snowpack, then the trend line will be upward. For example, 1967 through 1976 shows a period when snowpack was above-average. If there is a long period of below-average snowpack, then the trend line on the graph will be downward. A period of below-average snowpack is evident from 1998 to 2005.

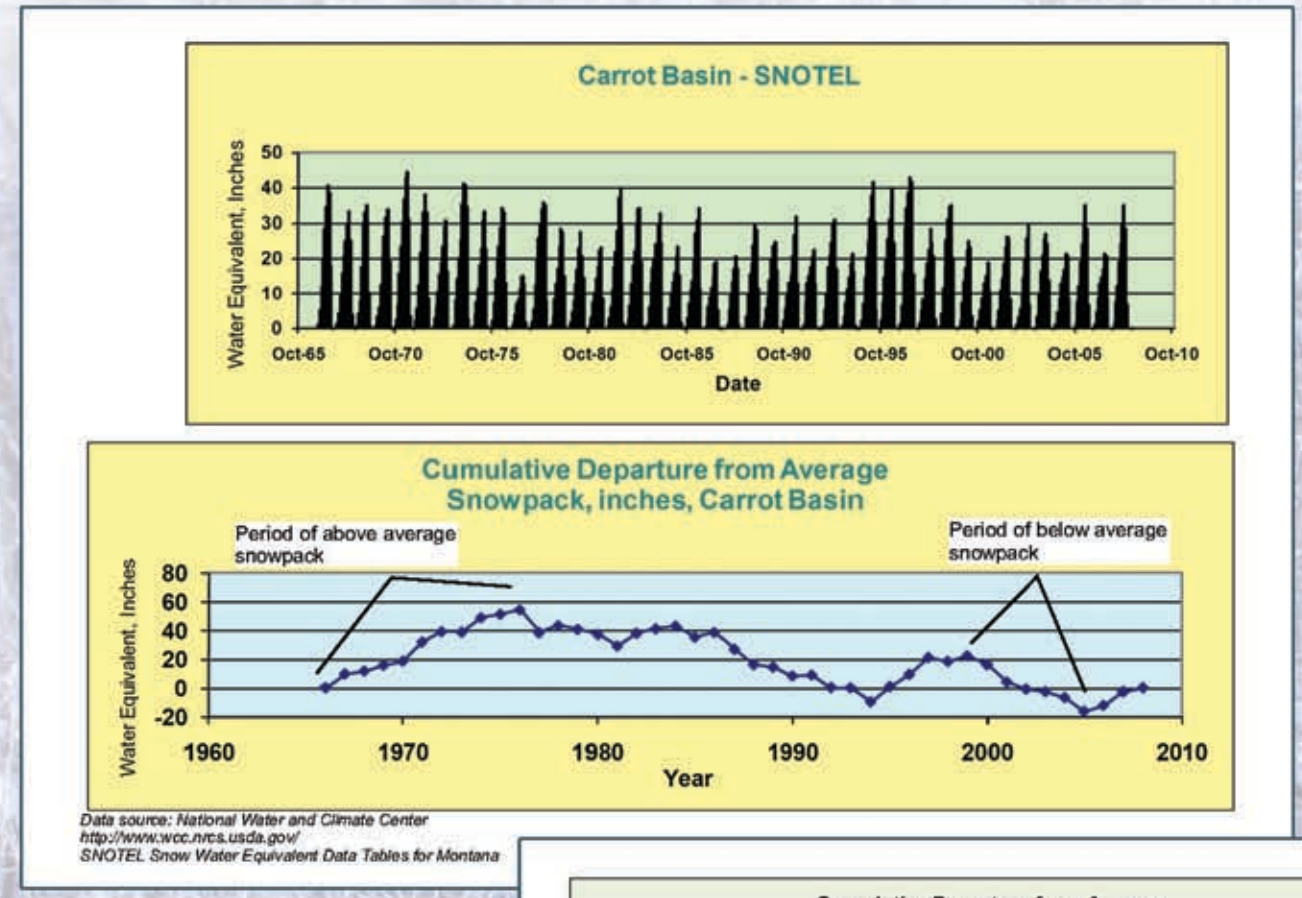

Figure 6 *Snowpack water equivalent from Carrot Basin – Gallatin Valley.*

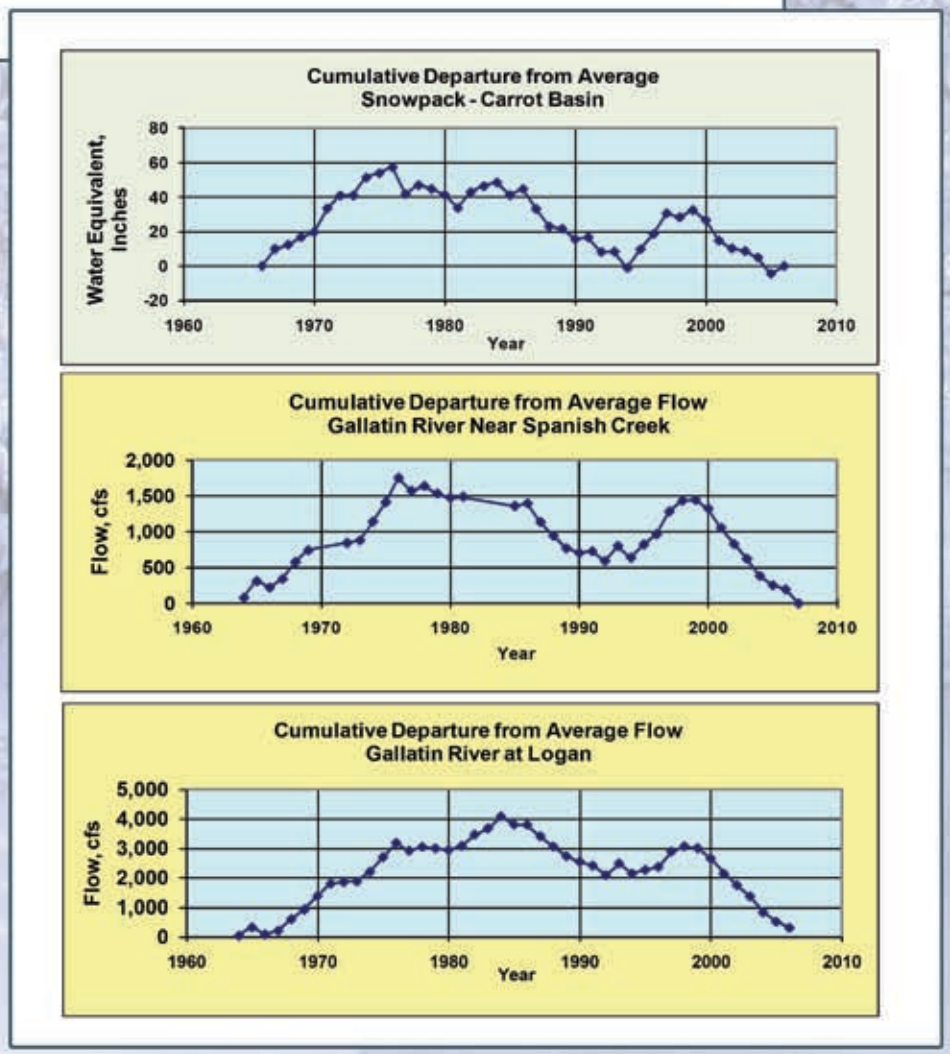

Figure 7 *An example of streamflow cumulative plots versus snowpack.*

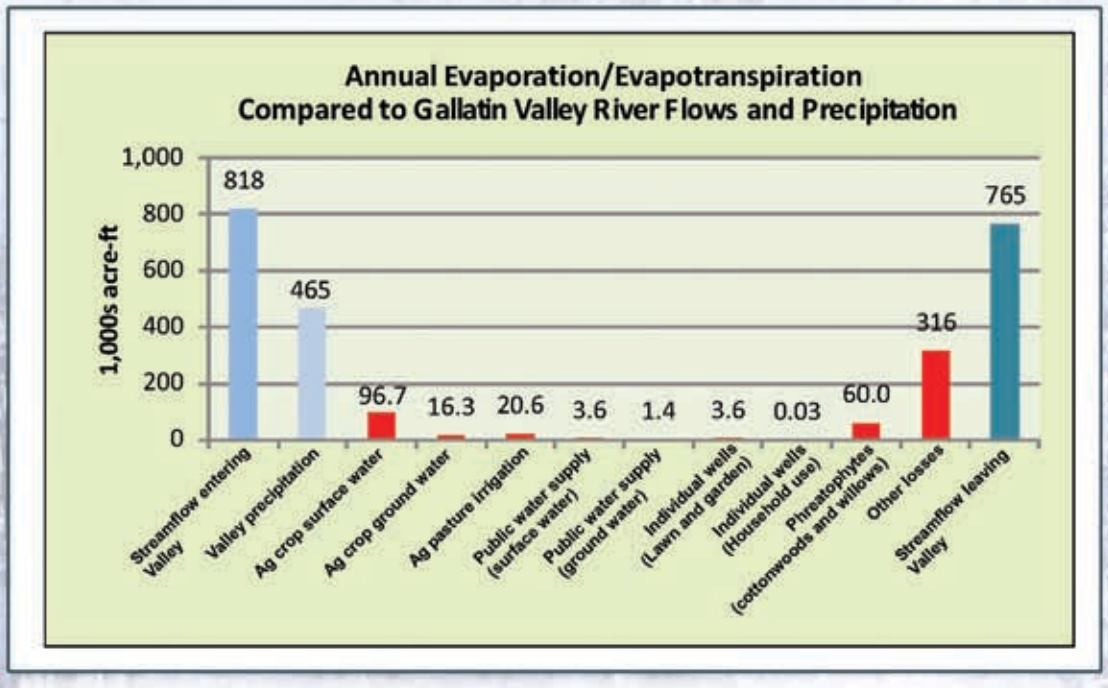

Figure 8 *A relative comparison of evaporation, evapotranspiration, and consumptive uses to precipitation and streamflow entering and leaving the Gallatin Valley.*

In essence, the streamflows in the valley are highly dependent upon the snowmelt from each year's given snowpack. What is very useful is to compare the cumulative departure plots for snowpack and for streamflow as shown in Figure 7. The similarities are striking, as the streamflows tend to mirror the snowpack. Figure 7 demonstrates that the primary reason for decreases in streamflow observed from 1998 to 2006 has been drought.

What Is the Water Consumption in the Gallatin Valley?

Figure 8 provides a more detailed accounting of the water entering and leaving the valley each year. A total of about 518,000 AF evapotranspires from the Gallatin Valley each year. Agriculture irrigation accounts for about 113,000 AF of this evapotranspiration. About 5,000 AF of groundwater is used each year for public water supplies and by individual homeowners with small domestic wells. This is about one percent of all evapotranspiration that occurs in the valley in a given year.

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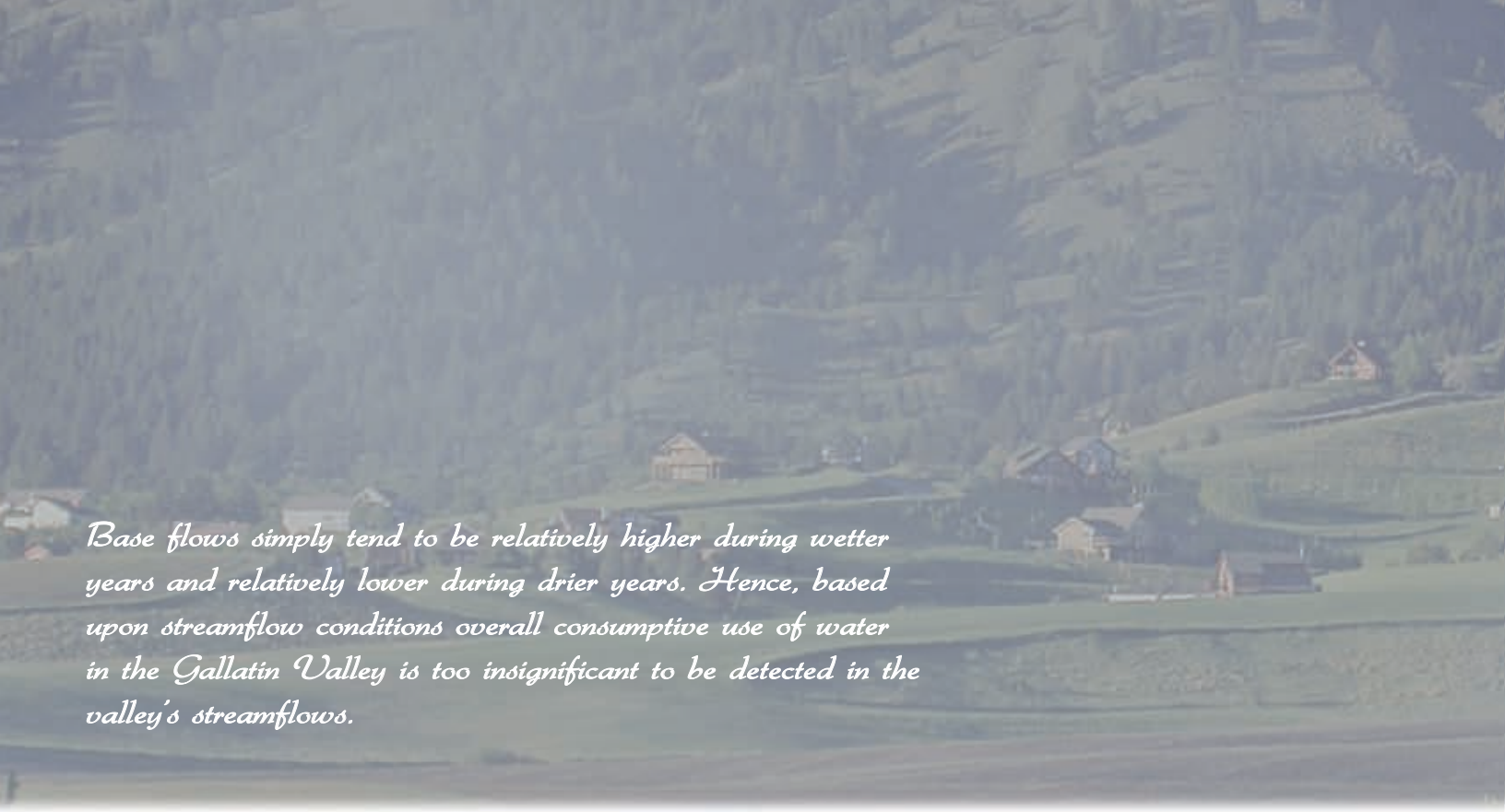


Base flows simply tend to be relatively higher during wetter years and relatively lower during drier years. Hence, based upon streamflow conditions overall consumptive use of water in the Gallatin Valley is too insignificant to be detected in the valley's streamflows.

One of the more significant factors affecting the water budget in the Gallatin Valley is the amount of water consumed by water-loving plants known as phreatophytes. The USGS (Hackett, 1960) estimated that between 30,000 and 90,000 AF of the overall water budget each year is associated with phreatophyte consumption. Hence, comparatively speaking, the consumption associated with phreatophytes overwhelms any other groundwater consumption in the Gallatin Valley.

Has Overall Water Consumption in the Gallatin Valley Changed Over Time?

Another factor that requires more evaluation is the nature of land use transitions in the valley. There are clear indications that significant proportions of both irrigated and non-irrigated farm land have been replaced by subdivisions. The key issue that needs to be resolved is whether these changes have led to either a net increase or decrease in consumptive use. If there has been a net change, it is not evident in the streamflow data of the Gallatin Valley, which are discussed in a later section of this report.

Has Groundwater Storage Changed in the Gallatin Valley?

Another component of the water budget is aquifer or groundwater storage. The total estimated groundwater storage for Gallatin Valley is at least 29 million AF. This is the equivalent to about 9.4 trillion gallons of water. Figure 9 on the next page provides another comparison showing annual water uses compared to groundwater storage. As this figure shows, the amount of groundwater use by public and individual wells is extremely small when compared to total groundwater storage.

An examination of observation well water level data also is useful to determine if groundwater has been over-appropriated. In evaluating observation data that have been collected by MBMG for the Gallatin Valley, a few wells had shown declines during long drought. These wells have recently rebounded with the advent of more normal precipitation patterns in the Gallatin watershed. Hence, from a practical perspective, aquifer storage in the valley has remained relatively unchanged since the 1950s. Therefore, there is no evidence that overdrafts of groundwater are occurring in the Gallatin Valley.

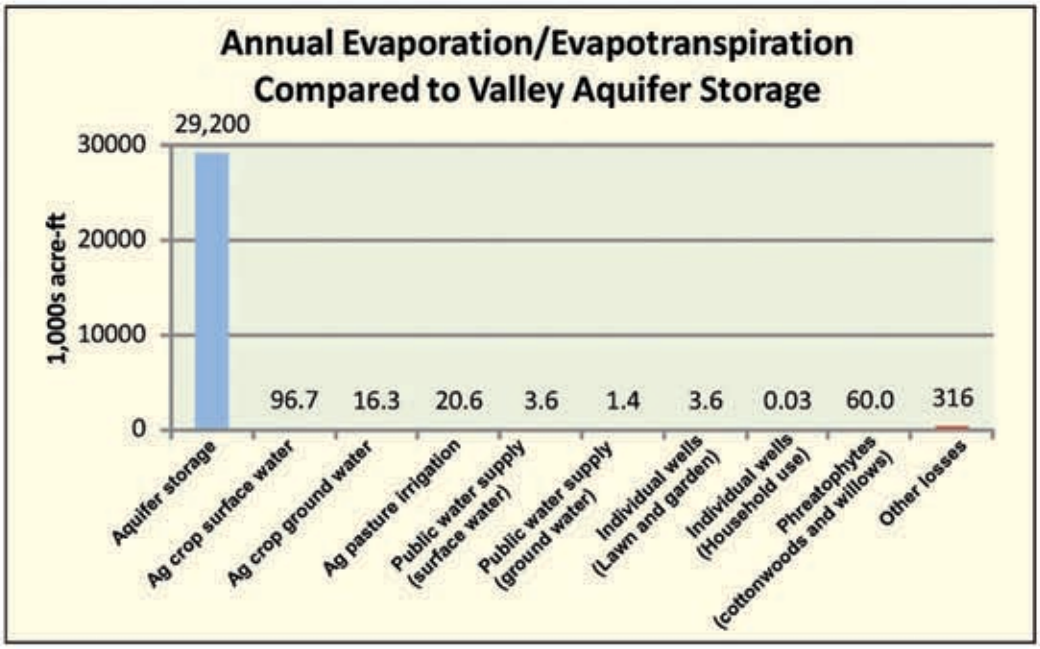


Figure 9 *A relative comparison of evaporation, evapotranspiration, and consumptive uses of aquifer storage for the Gallatin Valley.*

What About Seasonal Variations in Flow During Drought Periods?

Studies by NE&W of the streamflow data also were performed by evaluating annual trends, individual monthly trends, and daily low flows for streamflow, which included periods of drought in the Gallatin Valley (NE&W, 2008b). The goal was to determine if there was any evidence that base flow conditions had changed over time as well.

Groundwater development has been dispersed throughout the valley. Therefore, the effects on streamflow are distributed throughout all the streams in the valley. The culmination point of all the combined effects on surface water is finally manifested at the Logan gaging station. The maximum combined effects of groundwater use in the valley are relatively inconsequential even when evaluating the lowest daily flows ever recorded at Logan. Thus, there is no evidence of measurable changes in surface water flow in the Gallatin Valley associated with groundwater development.

In summary, the results of these studies did not reveal any evidence of long-term downward trends in streamflow. Any trends in base flows were directly correlated to climate conditions. Base flows simply tend to be relatively higher during wetter years and relatively lower during drier years. Hence, based upon streamflow conditions overall consumptive use of groundwater in the Gallatin Valley is too insignificant to be detected in the valley's streamflows.

...there is no evidence of measurable changes in surface water flow in the Gallatin Valley associated with groundwater development.

What Are the Projected Impacts of Increased Growth?

Using the U.S. Census Bureau projections for growth in Gallatin County, the projected increase in groundwater consumptive use for the Gallatin Valley is about 2,300 AF per year by 2030. When coupled with the estimated current individual well consumptive use of 3,600 AF, the total projected consumptive use is estimated to be about 5,900 AF per year by 2030. The change of 3,600 AF needs to be kept in perspective. For example, 765,000 AF of water leaves the Gallatin Valley each year at Logan, MT (see Figure 5 on page 10). Hence, a change of 3,600 AF represents a change of 0.5 percent. This change is simply too small to be measured in streams of the Gallatin Valley.

When the changes in irrigated acreage are taken into consideration, it is possible that this increased growth may lead to more water being left in the Gallatin Valley.

It should be noted that it is likely that a substantial portion of the development will occur on existing irrigated land. Hence, it follows that the net impact on streams in the valley will be less than the 5,900 AF quantified above. When the changes in irrigated acreage are taken into consideration, it is possible that this increased growth may lead to more water being left in the Gallatin Valley. For example, Slagle (1995) reported a significant reduction in irrigated acreage in the Gallatin Valley from 1952 to 1985. Furthermore, evaluation of infrared imagery by NE&W (2007) also demonstrates that irrigated acreage has declined with the growth of subdivisions.

Summary for Gallatin Valley

The relative amount of groundwater consumption remains very small in terms of the overall water budget. Any net change in consumptive use in the valley remains too small to be detected in streamflows of the Gallatin Valley. Furthermore, except for climate-related responses, groundwater levels and groundwater storage in the Gallatin Valley are currently about the same as in the 1950s.

More evaluation is recommended to determine if there has even been a net increase or decrease in consumptive use in the valley owing to the transition in land uses that are occurring in the valley.

Additional Areas of Investigation

NE&W examined three additional areas of Montana to determine if the findings made for the Gallatin Valley were representative statewide. The additional areas examined were the Bitterroot Valley (Ravalli County), Lewis and Clark County, and Missoula County. Again, the same approaches used for the Gallatin Valley were applied. With some minor exceptions, the results were generally the same as in the Gallatin Valley. The following subsections discuss the similarities and differences that were observed.

Bitterroot Valley (Ravalli County)

Ravalli County generally encompasses the Bitterroot River watershed in western Montana (see Figure 10). The Bitterroot watershed has been designated as a closed basin. This basin is bounded on the east by the Sapphire Mountain Range and on the west by the Bitterroot Mountains. Land elevations range from 3,200 to over 10,000 feet above sea level. About 70 percent of Ravalli County is federally owned and managed, including the Bitterroot and Lolo National Forests and the Selway Bitterroot Wilderness. Ravalli County has seen relatively rapid growth in population and subdivisions. Most of the growth in this county has occurred within the valley portion of the watershed.

Figure 10 *Bitterroot Watershed and Ravalli County.*

Some key results of NE&W's evaluation for this closed basin are as follows:

- Streamflow in the Bitterroot Valley is dominated by the influence of mountain snowpack.
- Consumptive use from current groundwater development is relatively small compared to other uses of water. The level of groundwater development is too small to be detectable or measurable in the streamflows of the Bitterroot River, even during seasonal low-flow periods or during drought.
- Groundwater levels and, hence, aquifer storage have remained relatively constant in the Bitterroot Valley. This conclusion is also shared by MBMG (2008).

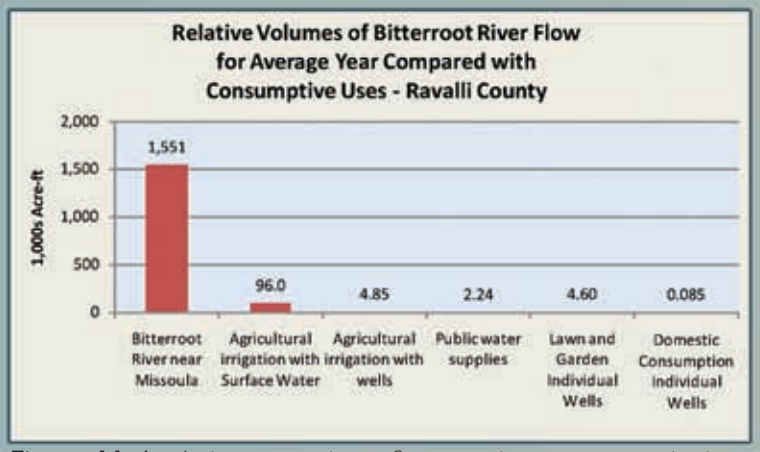


Figure 11 *A relative comparison of evaporation, evapotranspiration, and consumptive uses to streamflow leaving the Bitterroot Valley.*

Figure 11 provides some water budget comparisons of various consumptive use factors for the Ravalli County portion of the Bitterroot Valley. In summary, there were no substantive differences in the conclusions made for the Bitterroot Valley in comparison to the Gallatin Valley.

Lewis and Clark County

Lewis and Clark County is located in west-central Montana (see Figure 12). The Continental Divide splits the county into two drainage basins, the Columbia to the west and the Missouri to the east. The Upper Missouri is designated as a closed basin. About half of Lewis and Clark County's area of 3,477 square miles is mountainous – primarily national forest. Most of the population resides in Helena and the Helena Valley. The City of Helena is located on the mountain edges and in the valley proper. The Missouri River flows through the valley towards the north and is characterized by Canyon Ferry, Hauser, and Holter dams.

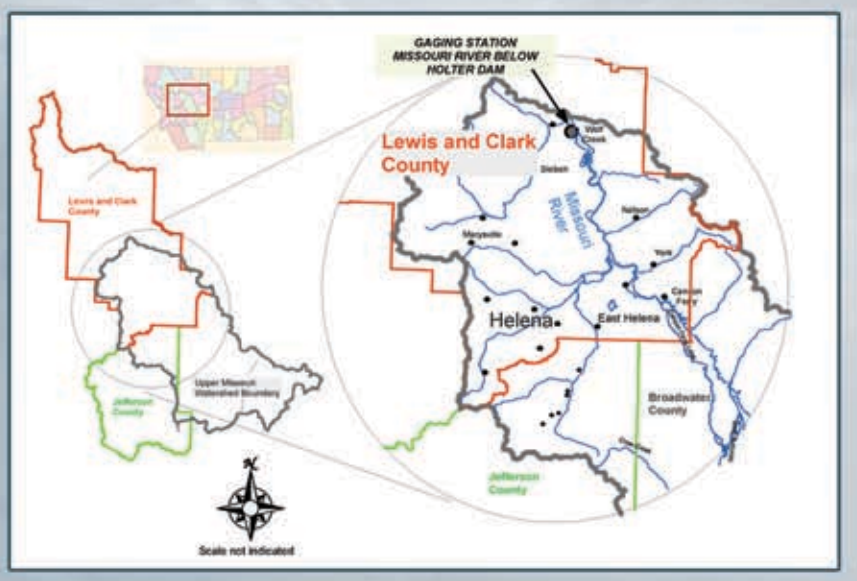


Figure 12 *Upper Missouri Watershed and Lewis and Clark County.*

Most of the irrigation in the project study area occurs in the Helena Valley. This irrigation water is mainly piped in from the Missouri River (Canyon Ferry). Aside from natural climatic factors, the most dominant factor affecting streamflow of the Missouri River in the portion of the Upper Missouri at Lewis and Clark County are reservoir operations. First, the flows of the Missouri River are stored and then released. Second, evaporation from these reservoirs is substantial. In fact, this evaporation alone grossly exceeds all groundwater use in Lewis and Clark County.

Some key results of NE&W's evaluation for this closed basin are as follows:

- Streamflow in this portion of the Missouri River is influenced by mountain snowpack and also by reservoir operations.
- Consumptive use from current groundwater development is relatively small compared to other uses of water. The level of groundwater development is too small to be detectable or measurable in the streamflows of the Missouri River, even during seasonal low-flow periods or drought.
- Groundwater levels and, hence, aquifer storage have remained relatively constant over a substantial portion of Lewis and Clark County with the exception of the North Hills area, which is located north of Helena. Several wells in that area have shown long-term declines. MBMG attributes most of this decline as follows: "Although the decline in some wells is near the most developed part of the North Hills, the decline has also been measured in wells where development is minimal. The decline, therefore, is probably related more to climatic anomalies and to a lesser extent over drafting by well withdrawals." (Madison, 2006). NE&W (2008) conducted additional evaluations of other wells in Lewis and Clark County and determined that there was no evidence of general declines in water levels. In effect, with the exception of the North Hills area, water levels in Lewis and Clark County wells and, hence, aquifer storage have remained relatively constant over time.

- Figure 13 provides some water budget comparisons of various consumptive use factors for the Lewis and Clark county portion of the Upper Missouri River closed basin.

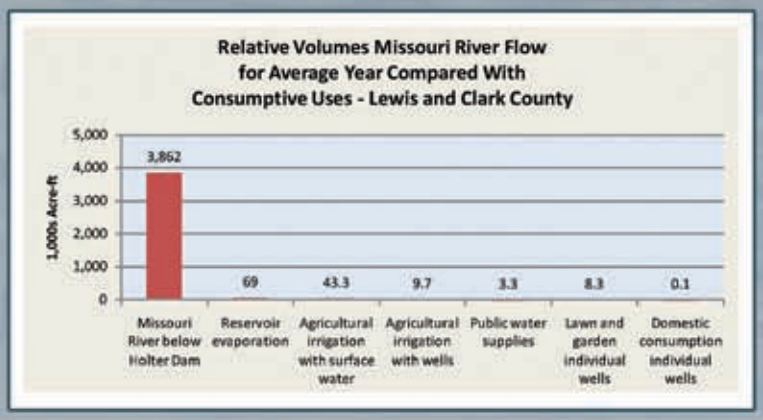


Figure 13 *A relative comparison of evaporation, evapotranspiration, and consumptive uses to streamflow in the Missouri River below Holter Dam.*

North Hills Controlled Groundwater Study

From an overall water budget perspective, there were no substantive differences in NE&W conclusions for Lewis and Clark County than from the other areas of study except for observations made in the North Hills area of Helena, where water levels have shown recent declines. However, even in the North Hills wells where declines were observed, the Montana Department of Natural Resources and Conservation ("DNRC"), in denying a petition to designate a controlled groundwater area in the North Hills, found that the majority of the well level declines were attributable to climactic conditions (Proposal for Decision, 2008). DNRC further found, "The evidence does not support the conclusion that water levels in wells in the temporary [controlled groundwater area] have declined excessively. While some water level declines have been experienced north of the Helena Valley Irrigation Canal, natural precipitation patterns have an impact" (page 30, Id.). In short, DNRC concluded that "the impacts and moderation of declines do not rise to the level of a public health, safety, or welfare concern because there is no showing that water right owners will not be able to reasonably exercise their water rights" (pages 30-31, Id.).

Missoula County

Missoula County covers about 2,600 square miles in the Columbia Basin in western Montana (see Figure 14). The county consists of high mountains with sediment-filled valleys. Most of the county drains to the Clark Fork River. About half of the county is publicly-owned federal and state lands.

Missoula County encompasses portions of three key basins: the Middle and Upper Clark Forks and the Bitterroot. The Upper Clark Fork is a closed basin. The primary focus of the evaluation was placed in the immediate metropolitan area of Missoula County.

Some key results of NE&W's evaluation for the Upper Clark Fork Basin in Missoula County are as follows:

- Streamflow in the portion of the Clark Fork River near Missoula is influenced by mountain snowpack.
- Consumptive use from current groundwater development is relatively small compared to other uses of water. The level of groundwater development is too small to be detectable or measurable in the streamflows of the Clark Fork River, even during seasonal low-flow periods or drought.
- Groundwater levels and, hence, aquifer storage have remained relatively stable in Missoula County.
- There has been a definitive decline in irrigated agricultural acreage in Missoula County. Hence, from a water budgeting perspective, it is likely that overall consumptive use in Missoula County has decreased over time (see Figure 15).

In summary, from an overall water budget perspective, the conclusions made for the Missoula County evaluation were very similar to those made for the other watersheds. The primary difference is that in Missoula County there is definitive evidence of land use transitions away from irrigated acreage, resulting in a corresponding net reduction in water consumption.

Figure 14 *Missoula County and stream gages near Missoula.*

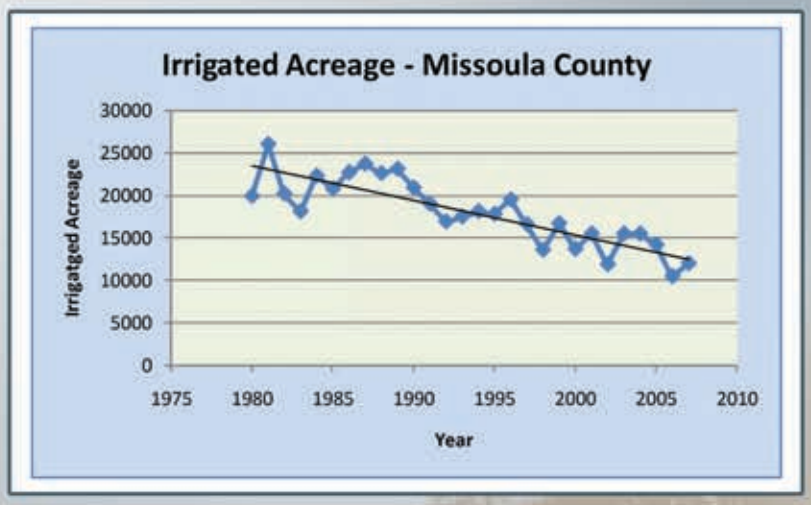


Figure 15 *Trend in Missoula County irrigated acreage obtained from U.S.D.A. National Agricultural Statistics Service (2008).*

Montana Bureau of Mines & Geology Case Studies

MBMG conducted case studies in three watersheds – the Lower Beaverhead, the Bitterroot, and the Gallatin Valley (MBMG, 2008) – with findings that generally comport with the findings of NE&W. Some key similarities include the following:

Lower Beaverhead Watershed Case Study: The magnitude of stream depletions described for a case study involving the Beaverhead River were projected to be small and within streamflow measurement errors. NE&W has also determined this to be true in all of the watersheds that NE&W examined for this report. MBMG also noted the significance of woody phreatophytes and their impact on the overall water budget, especially due to their proximity to streams. Active management of phreatophyte abundance is recommended to avoid negatively impacting the availability of water resources in the closed basins.

Bitterroot Watershed Case Study: The findings described for the Bitterroot watershed were consistent with the findings of NE&W. According to MBMG:

> *Bitterroot Valley groundwater use has not produced measurable impacts on a basin-wide scale to Bitterroot River base flows or groundwater storage. Observed variability in base flows is more strongly correlated to annual precipitation variability than to groundwater development. Consumptive groundwater use represents a minor fraction (1 percent) of the estimated annual groundwater discharge from the shallow basin-fill aquifer. On a basin-wide scale, there has been little capture due to groundwater development, and long-term water level trends are mostly stable (page 102, MBMG, 2008).*

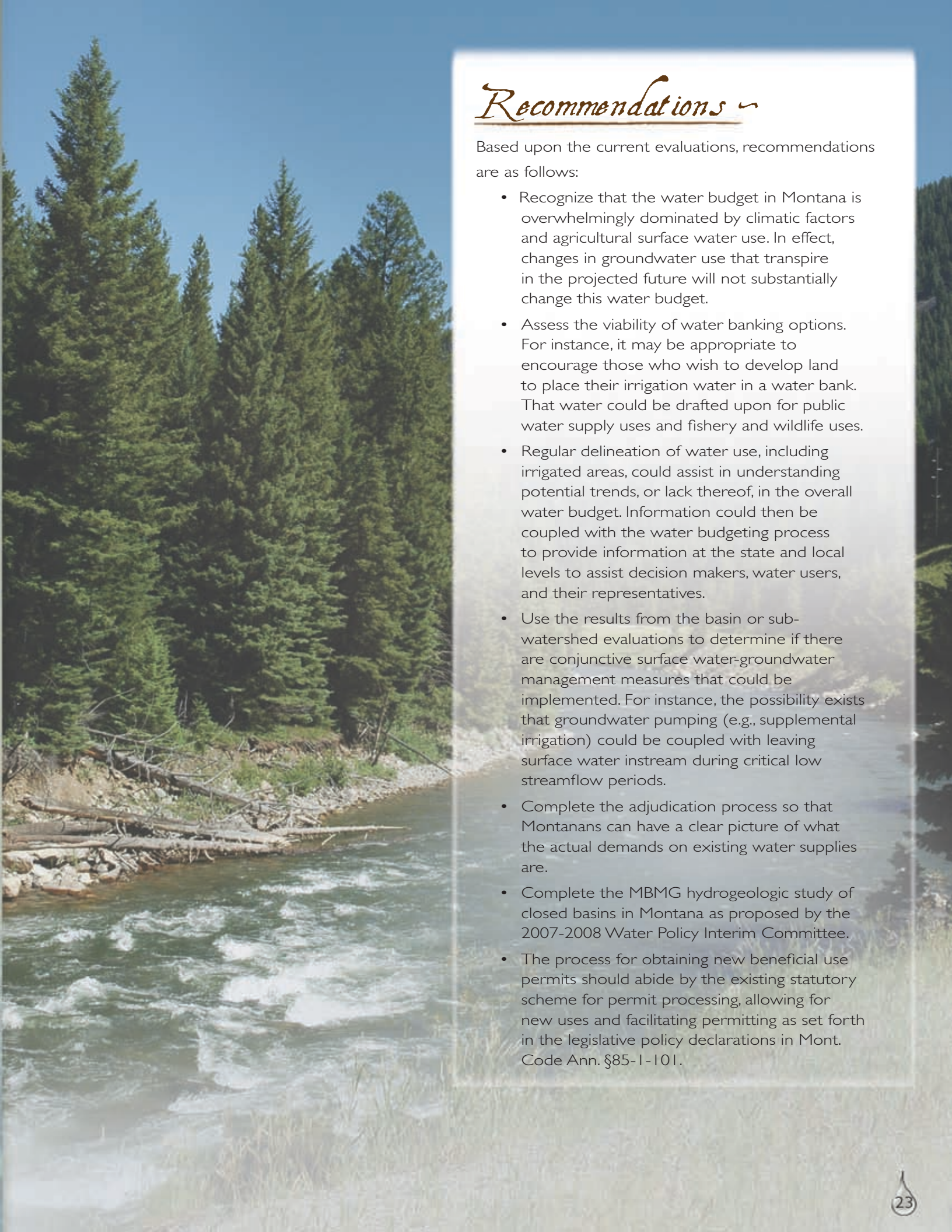
Gallatin Valley Watershed Case Study: The findings described in the Gallatin Valley portion of MBMG's case studies generally conform with evaluations conducted in the Gallatin Valley by NE&W. The MBMG report provides yet another example of why one would not expect the limited groundwater development that exists in the valley to be detectable in the streamflow measurement records in the Gallatin Valley.

Furthermore, both the MBMG and NE&W studies demonstrate the need to quantify all the relevant factors that affect streamflow before conclusions are drawn about the overall system response to groundwater development.

Summary

Water budget evaluations of the Gallatin and Bitterroot Valleys and Lewis and Clark and Missoula Counties were performed by NE&W. Databases evaluated include climatic data (precipitation, including SNOTEL and local climate data), streamflow (focus on long-term streamflow data collected for the relevant streams), and groundwater level data (MBMG Groundwater Information Center data). Based upon the evaluations, the following were key findings:

- Streamflows depend principally upon each given year's mountain snowpack. Snowpack as measured by water equivalent since the late 1990s has been below average. This has led to a period of lower than average streamflows.
- By far the most significant human-related influence on streamflow is surface water diversion for irrigation. Reservoir evaporation was a significant factor for Lewis and Clark County in the Upper Missouri River basin. Groundwater use, particularly groundwater appropriation by public water supply wells and exempt wells, is very small when compared to streamflow diversions for irrigation.
- Groundwater levels and, hence, aquifer storage have remained relatively constant from year to year.
- There is no evidence that the overall consumptive water use has increased with the growth of subdivisions and their accompanying use of groundwater. The primary reason for this is that many of these subdivisions have been placed in areas where agricultural irrigation activity has historically occurred. Consequently, residential development does not constitute a new use of water, but, rather, a replacement of an old use with lower consumption rates.
- Water budgeting assessments show no measurable evidence of so-called "cumulative impacts" of exempt wells, public water supply wells, or even agricultural irrigation wells on streamflows. In effect, any net cumulative effect, if it exists, is simply too small to be discerned.
- Projections of future water demands on groundwater predict that the impacts of groundwater development by 2030 will not be detectable or observable in streams.



Recommendations

Based upon the current evaluations, recommendations are as follows:

- Recognize that the water budget in Montana is overwhelmingly dominated by climatic factors and agricultural surface water use. In effect, changes in groundwater use that transpire in the projected future will not substantially change this water budget.
- Assess the viability of water banking options. For instance, it may be appropriate to encourage those who wish to develop land to place their irrigation water in a water bank. That water could be drafted upon for public water supply uses and fishery and wildlife uses.
- Regular delineation of water use, including irrigated areas, could assist in understanding potential trends, or lack thereof, in the overall water budget. Information could then be coupled with the water budgeting process to provide information at the state and local levels to assist decision makers, water users, and their representatives.
- Use the results from the basin or sub-watershed evaluations to determine if there are conjunctive surface water-groundwater management measures that could be implemented. For instance, the possibility exists that groundwater pumping (e.g., supplemental irrigation) could be coupled with leaving surface water instream during critical low streamflow periods.
- Complete the adjudication process so that Montanans can have a clear picture of what the actual demands on existing water supplies are.
- Complete the MBMG hydrogeologic study of closed basins in Montana as proposed by the 2007-2008 Water Policy Interim Committee.
- The process for obtaining new beneficial use permits should abide by the existing statutory scheme for permit processing, allowing for new uses and facilitating permitting as set forth in the legislative policy declarations in Mont. Code Ann. §85-1-101.

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Evaluaton of
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One South Montana Avenue, Suite M1 • Helena, Montana 59601
406.443.4032 • www.montanarealtors.org
mtmar@montanarealtors.org