Teton River Distribution Project Guidance

Montana Department of Natural Resources and Conservation
Water Management Bureau
Helena, MT
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Introduction

This document was developed in response to a request by water commissioners and water users to create target flows and guidance for the Teton River Distribution Project. The Water Management Bureau of the Department of Natural Resources and Conservation (DNRC) in worked in-cooperation with Teton River water commissioners to create this document. The goal of this living document is to provide hydrologic data to assist water commissioners when distributing the water resources of the Teton Watershed.

Target Flow Development

A Target Flow is defined for the purpose this document as the minimum flow rate needed to: 1) ensure one or more water use demand(s) are met or, 2) achieve a desired instream flow condition. Target Flow rates are referenced to stream gage and are measured in cubic feet per second (cfs).

Target flows for the Teton River Distribution Project are established to guide the distribution of water according to priority date in areas of the river where natural processes[1] make water distribution more challenging. Several sources of data are used to estimate target flows including: streamflow, groundwater elevation, principles of hydrology and hydrogeology, and local experience. It is expected that, with trial and error, monitoring, and installation of additional real-time gages, improvements can be made to refine target flows to more effectively distribute water resources in the Teton Watershed (See map on Page 14).

2017 marked the first year of the Teton River Distribution project. Water commissioners were present on the Lower Teton River, Upper Teton River, Spring Creek, Muddy Creek, and Deep Creek.

Low Water Years

Low water years present unique challenges to water distribution. It may be feasible to use the Springhill Reach to maintain flow in Spring Creek and the Teton River downstream during times of low supply. For example:

- The Springhill Reach could be used to absorb and store rapid runoff from spring rains or runoff events, providing sustained flow downstream.
- The retention time (approximately 80 days) of water "stored" within the reach, can be utilized to stretch downstream supply during times of low flow.

Knowledge of the system, monitoring, trial and error and adaptation will be key to development of a more refined and effective plan of distribution during low water years.

Springhill Reach

Year round demands for storage and irrigation water limit the amount of water flowing into the Springhill Reach. Historically, water users on the Teton River near Choteau bypassed the Springhill Reach using the Bateman Ditch. The Bateman Ditch had been used as a "management tool" to deliver

[1] Such as loss of surface water to the alluvial aquifer, riparian evapo-transpiration, free water evaporation and prolonged periods of hot and dry weather.

water to the Broken O Ranch. The use of the Bateman Ditch to bypass the Springhill Reach was curtailed for the 2017 irrigation season on order of the Montana Ninth Judicial District Court, Teton County, on February 16, 2017. Use of the Bateman Ditch as a water management tool was permanently enjoined on February 6, 2018.

Target flows in this document are not specifically designed to deliver water to Spring Creek. However, Teton River target flows for the Springhill Reach (designed to meet Teton River water rights near Choteau) will increase flow in Spring Creek (as a by-product) due to the strong hydrologic connection between Spring Creek and the Teton River (i.e. the Springhill Reach).

Target Flows

1. **Delivery of Teton River and Spring Creek Rights near Choteau Using the Springhill Reach**

Characteristics of the Springhill Reach

Maintaining flow rates at the DNRC Teton River Gage (Teton River above Springhill) at proposed Target Flows is intended to increase the likelihood that water is present in sufficient quantities in the Teton River below the Springhill Reach near Choteau. Water that enters the Springhill Reach is usually lost to the Teton Valley Aquifer that underlies the Teton River, resulting in a dry riverbed.

Water rises downstream as surface flow in the Teton River and Spring Creek or it continues to flow downgradient as groundwater. Uncertainties exist about "how much" and "when" lost Springhill Reach water will arrive downstream. Some general guidance is:

- Surface water delivered through the Springhill Reach combines with groundwater flowing down valley from the mountains and losses on the Teton River above the Springhill Reach. All of which contribute to sustaining: Spring Creek, the Teton River near Choteau, and groundwater in the Choteau Area.
- It is unlikely that achieving target flows into the Springhill Reach will create surface water flow through the entire Springhill Reach.
- It is estimated that water lost in the Springhill Reach will appear in the following locations and volumes:
    - ~36% will return to the Teton River near Saylor Lane Bridge[2].
    - ~30% will return to the lower portions of Spring Creek[3].
    - The rest ~34% will either resurface in lower stretches of the Teton River or will continue to flow downgradient as groundwater[4].
- The hydraulic properties of the Springhill Reach provide some flexibility for the commissioner. Flow into the Reach can be constant or vary from day to day, with nearly the same outcome downstream if the monthly average inflow is the same (Figure 1).

[2] Teton River flows at Saylor bridge were estimated by a regression equation and field measurements. See the appendix for more information.
[3] Based on measured flow at the DNRC Lower Spring Creek gage.
[4] Estimated as the residual.

- A delay of 11-18 days occurs between the infiltration of water in the Springhill Reach and the initial return of water downstream (Figure 3). This makes it necessary to plan downstream demands with a lead time in weeks rather than days.
- For every day of water that enters the Springhill Reach, downstream flows are expected to be sustained for four days.[5]
- If streamflow into the Springhill Reach ceases, the Reach will require "charging" to raise groundwater levels in the alluvial aquifer and increase downstream flow.
- Flow out of the Reach will be sustained as long as flows into the Springhill Reach are maintained at suitable levels to prevent dewatering of the underlying Teton Valley Aquifer. Loss of the initial "charge" to the aquifer resets the delayed process of delivery of water through the Springhill Reach.

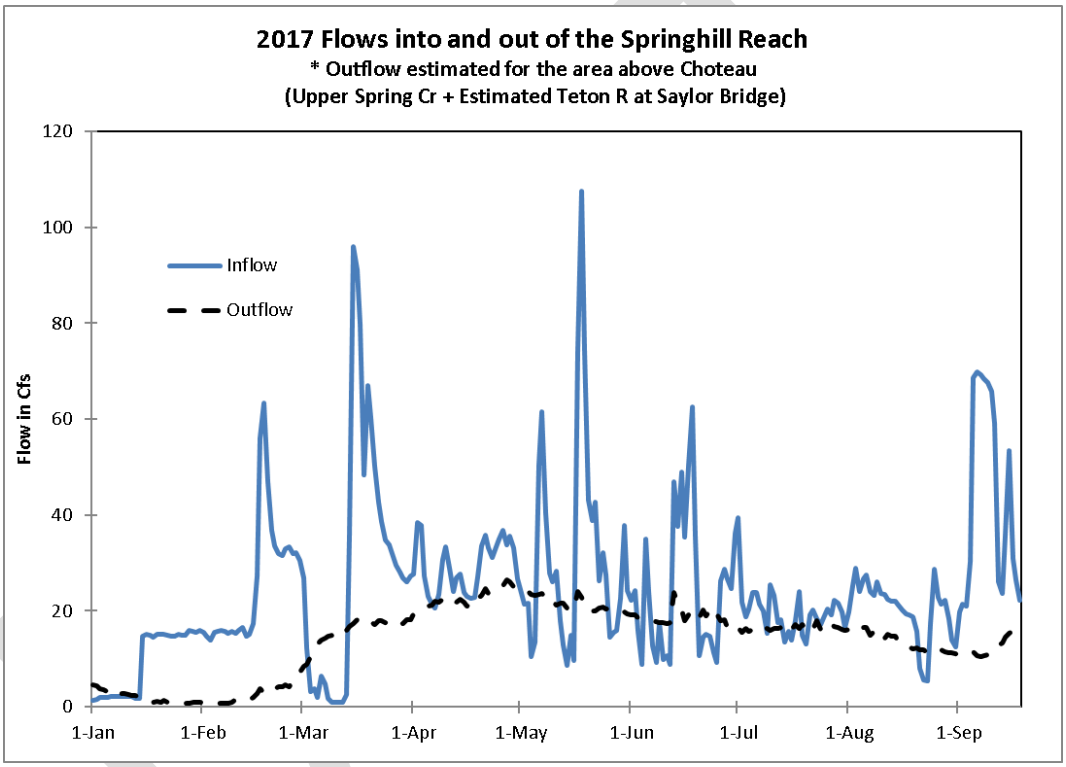

Figure 1. Flow into (DNRC Teton R. above Springhill Gage) and flow out of the Springhill Reach for the area above Choteau (DNRC Upper Spring Cr Gage and Estimated Teton R. at Saylor Bridge Flow)

Target Flows

Managing water levels in the Teton Valley Aquifer year-round, may lessen the burden of refilling the aquifer when water demands are high (i.e. sustaining a minimum flow into the reach (November-February) would prevent a substantial flow being required in March/April to fulfill downstream rights).

The following target flows (Table 1) could maintain aquifer levels during times of non-irrigation and to fulfill downstream water rights in priority during the irrigation season. The target flows into the

[5] Based on August 2016 data. Water entered the reach for 22 days, downstream flows increases and were sustained for 87 days. 2017 data suggest a similar retention time See Figure 6 in the appendix.

Springhill Reach were increased by 5 cfs in August (from 15 to 20 cfs) based on actual deliveries by the water commissioner into the Springhill Reach in 2017, and the performance of outflows from the Reach (Figure 2).

	DNRC Gage Teton River above Springhill	Deep Creek below Highway 287	USGS Gage Teton River Dutton	USGS Gage Teton River at Loma	Muddy Cr at Collins
Fall/Winter	10	NA	NA	NA	NA
March	15	NA	NA	NA	NA
April	20	NA	NA	NA	NA
May	25	Wet	27	Wet	Wet
June	25	Wet	27	Wet	Wet
July	20	Wet	27	Wet	Wet
August	20**	Wet	27*	Wet	Wet
September	15	Wet	27*	Wet	Wet

Table 1: Target flows for the Teton River Distribution Project. * See text on page 11 for additional information. ** Target flow was increased based on 2017 data, cooler and wetter August weather could provide room to reduce the flow to 15 cfs. NA- Not Applicable because water is present is sufficient quantities and demands are minimal. Wet- is defined as a surface water present in the channel.

Careful observation of flow on the Teton River downstream of the Springhill Reach will be helpful to administering water through the Springhill Reach. A stream gage maintained by the DNRC in the area near Saylor Bridge may be warranted to improve distribution.

Performance of suggested 2017 target flows for delivery of water rights below the Springhill Reach can be assessed in Figure 2. Some general points based on 2017 data are:

- Inflows met or exceeded proposed target flows for most months except November and December.
- Inflows into the reach are greater than the Teton River water rights (near Choteau) for which the target flows were created. Flow into the Springhill Reach is also realized and diverted on Spring Creek and the Teton River below Choteau.
- Outflows from the Springhill Reach were adequate to meet diversion needs on the Teton River above Choteau.
- August 2017 inflows into the Springhill Reach were 5 cfs greater than initial proposed inflows. Based on the flow below the Springhill Reach, the proposed inflows were increased to mimic the measured August 2017 deliveries.
- DNRC regression estimates for flow at Saylor Bridge appear to have underestimated available water in May, June and July (i.e. measured diversions were 24% higher than predicted flow). Gains in the Teton River below the bridge and/or regression error are likely factors.
- Year-round flow into the reach should prevent the need to deliver higher than proposed flows like those observed in February-May 2017.

- If “extra” water is available in May and June, higher flow into the reach could be beneficial during times of lower flows in (July – September).
- Higher than proposed flows in September are the result of releases in response to a call for water from the Lower Teton River.

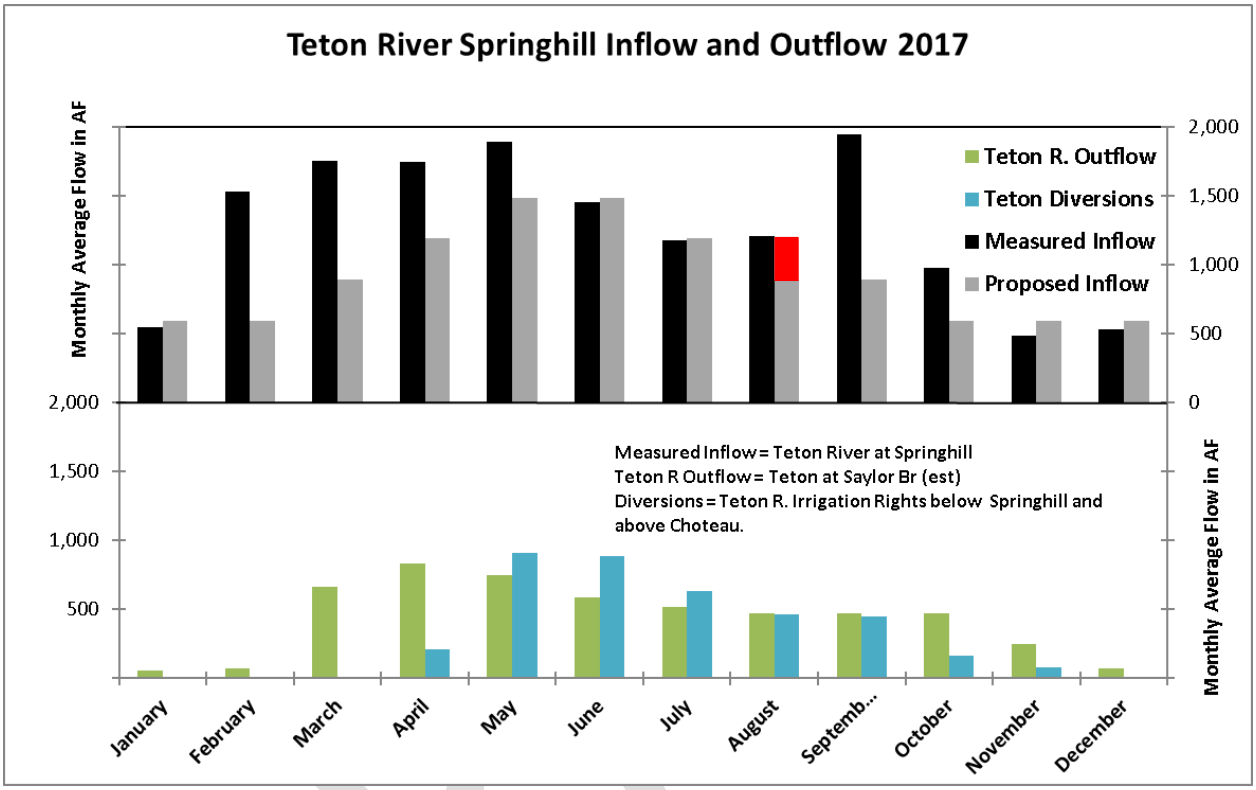

Figure 2. Flow into (DNRC Teton River above Springhill Gage) and flow out of the Springhill Reach for the area above Choteau (DNRC Estimated Teton River at Saylor Bridge Flows). Proposed target flows shown shows the proposed increase (**Red** in August) based on 2017 data. **Diversion** data was obtained from water commissioner records.

Timing

The timing of when increases or decreases in flow into the Springhill reach will appear downstream vary based groundwater elevations in the aquifer. Calls for water into the Springhill Reach by Lower Teton stock water right holders in August 2016 and September 2017 (Figure 3) provide an illustration of flow response under two different management scenarios: 1) the Bateman Ditch used as a water management tool in 2016, and 2) the Bateman Ditch not used as a water management tool in 2017. Flow downstream of the Springhill Reach was observed to increase seven days earlier in 2017 (11 days) than in 2016 (18 days). The maximum volume of flow from the call lagged another (7-13 days) behind the first arrival of called water.

Results of using the Springhill Reach for delivery of downstream water rights were:

- The Springhill reach received water every day of 2017.

- Constant flow increased the elevation of groundwater in the Teton Valley Aquifer.
- Increased groundwater levels rewetted reaches of the Teton River that were typically dewatered when water was diverted to the Bateman ditch.

The change in timing (shorter delivery) occurred because rewetting of the channel in these areas was not required (i.e. more water flowed on the surface in 2017 than in 2016, meaning, water spent more time flowing at a rate of feet/second instead of flowing underground at a rate of feet/day).

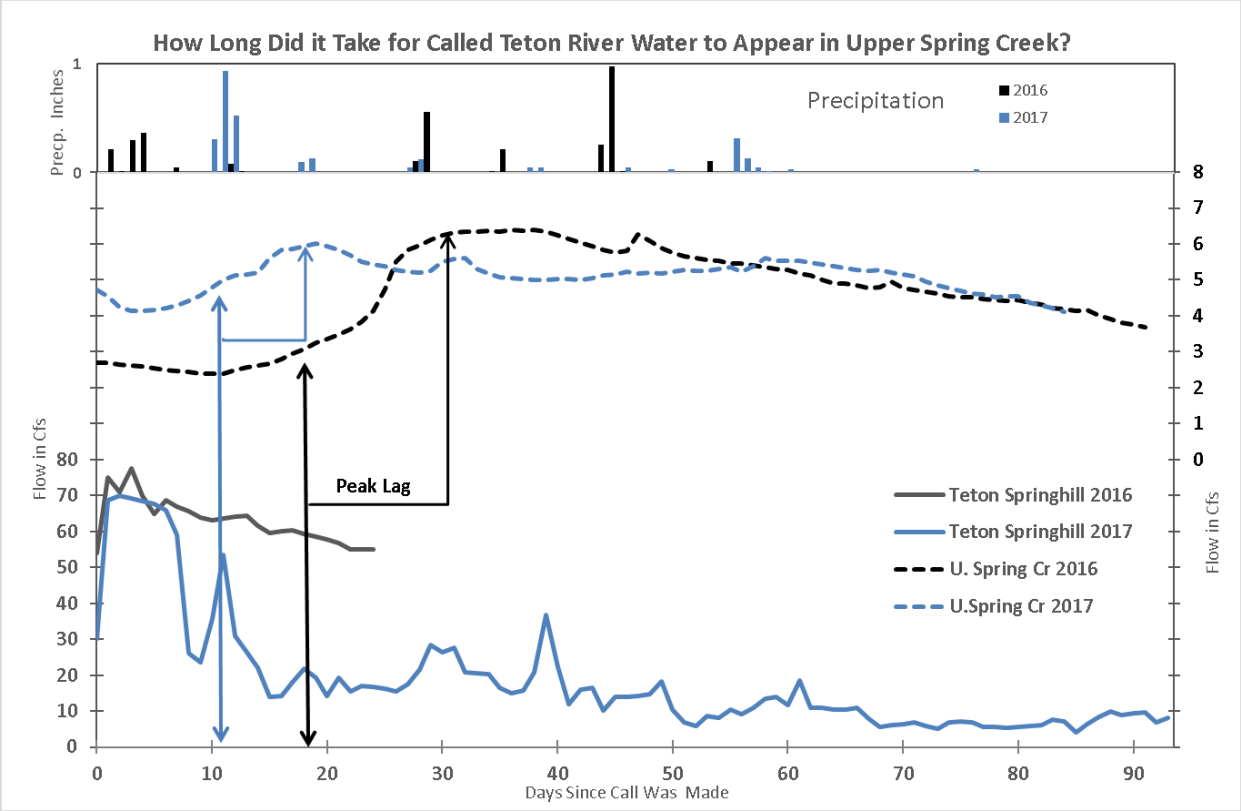

Figure 3: August 2016 streamflow of the Teton River water into the Springhill Reach and flow out of Upper Spring Creek. Precipitation at Choteau is plotted for reference.

The pulse of called water in 2016, demonstrates the ability of the Springhill Reach and the Teton Valley Aquifer to "store" and slowly release water. Downstream flows were found to be sustained for 87 days (See Figure 6 Appendix) by letting water into the Reach for 22 days. This indicates that water let into the reach in June, could help maintain downstream flow in August.

Forecasting Changing Groundwater Conditions in the Springhill Reach

In general, the Springhill Receives water from two sources: 1) surface water flowing down the Teton River and 2) groundwater in the alluvial aquifer. Data from studies near the Pine Butte[6] suggest that the

[6] Wylie, A., 1991, Hydrologic Investigation of Durr and McDonald Swamps, Teton County, Montana. Masters of Science Thesis, University of Montana.

highest groundwater levels in the Teton Valley Alluvial Aquifer coincides with the highest flows in the Teton River (May and June).

Optimal delivery of water through the Springhill Reach will require knowledge of when groundwater levels in the Springhill reach are rising and when they are declining. A monitoring well located near the DNRC Teton River above Springhill gage and a monitoring well located near the Junction of Highway 89 and the Teton Canyon Road would be ideal for assessing trends. Under current gaging efforts stream flow data from the Teton below South Fork (USGS), Upper Spring Creek (DNRC), and Teton River above Springhill (DNRC) gages provide the best source of data for predicting declining flows in the Springhill Reach. Some general guidance for water commissioners is:

- When flows at the USGS gage Teton River below the South Fork (USGS 06102500) drops below 100 cfs, snowpack runoff is over and the recession of groundwater flux from the Upper River into the Springhill Reach begins.
- At this point in time commissioners should start to carefully track flows in Upper Spring Creek and the Teton River near Saylor Bridge.
- When flows in Upper Spring Creek have declined for 20 consecutive days, commissioners should assess if flows into the Springhill Reach are adequate to meet Choteau area demands for the upcoming (1-2 months) based on the data (i.e. how many days of irrigation are left?), precipitation and temperature.
- Communication with the Lower River commissioner should start at this point to discuss trends in the Lower River flows and predicted needs.
- Adjustments of flow into the Springhill Reach should be made based on current and predicted Choteau area and Lower River needs.
- Upper Spring Creek flows dropped for 41 days in 2017 before a call for Upper Teton River water was made to satisfy Lower Teton Stock rights. Assessing the need to adjust Springhill Flows after 20 days should provide enough flexibility to commissioners to meet demands in a timely manner.

2. Teton River Stock and Irrigation Rights Dutton to Loma

The USGS Teton River near Dutton gage (USGS 06108000) usually represents the maximum supply of water in the Lower Teton River; in general, below the Dutton gage the Teton River does not gain any additional water from tributaries. Accordingly, the Dutton gage is the most appropriate gage for setting target flows (Table 1) to deliver Lower Teton River stock rights between Dutton and Loma.

Losses

Loss of water from: irrigation diversions/ET, riparian vegetation (ET), free water evaporation, and loss to the alluvium present a challenge to the distribution of stock rights over the 90 miles of the river from Dutton to Loma. Estimating losses on the Lower River are difficult due to limited data, the sheer size of the watershed and the length of the river. The best source of stream flow data for the area is from the 2016 DNRC Teton Watershed Study (TWS).

In general, there is no net loss of flow on the Lower River during the months of April, May, and June (Figure 4). A general explanation is that gains from runoff and precipitation offset irrigation demands and other losses during this time-period.

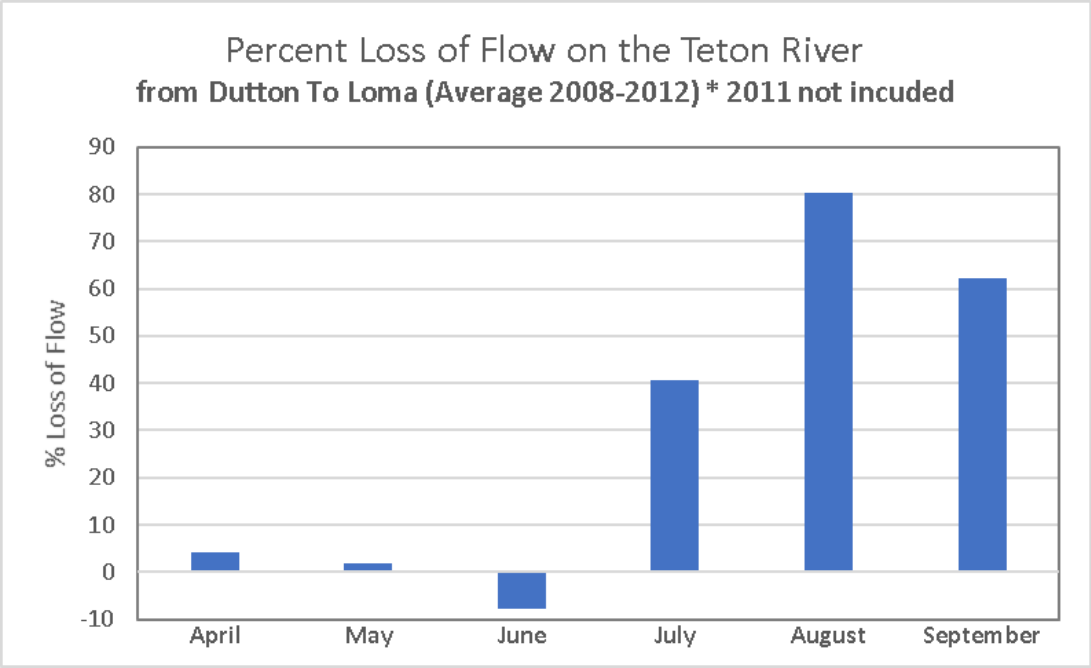

Figure 4: Average monthly losses (including Irrigation diversions) from the USGS Gages Dutton to Loma for the years: 2008, 2009, 2010 and 2012

The most significant losses (up to 100% of the flow) from the system begin to occur in July and can persist into September as water supply declines and temperatures rise. Irrigation diversions were measured and recorded for the first time on the Lower Teton River in 2017 as part of the Teton River Distribution Project. Based on 2017 data (Figure 5), irrigation diversions do not appear to be the dominate mechanism for the late summer loss[7].

[7] It should be noted that water consumed by irrigators on the Lower River reduces water available to recharge the River and the adjacent aquifer. The reduction in water (April-July) likely contributes losses that are observed after irrigation diversions shut down.

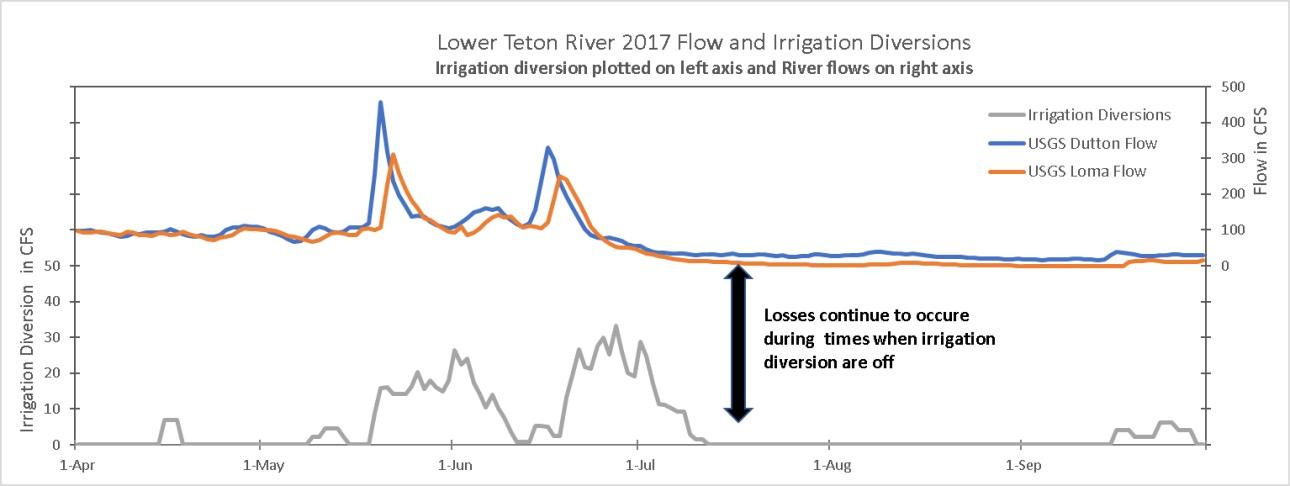

Figure 5: Teton River flow at USGS gages Dutton and Loma, and Teton river irrigation diversion from water commissioner records.

The exact cause of low flow loss is unknown, but it appears to be natural phenomenon (riparian ET, evaporation and seepage). Some general observations of water loss on the Lower River are:

- When flow at the USGS Gage Teton River at Loma (USGS 06108800) is greater than 30 cfs, little to no water is lost from the system except for irrigation diversions.
- When flow at Loma drops below 30 cfs, upstream irrigation diversions begin to cease and the percentage of flow lost increases significantly as flow decreases.
- Average losses (for flow conditions under 30 cfs at Loma) are 60%, but can increase or decrease dramatically responding to hydrologic, climatic and water use conditions.

Travel Time of Flow on the Lower Teton River

Three sources of data exist to estimate travel time of flow:

- DNRC and USGS field discharge measurements
- USGS and DNRC stream gage records
- Observations of the progression of called water by Lower Teton water users

Using USGS gaging records during high water events (greater than 200 cfs at Dutton) the travel time of flow peaks from Dutton to Loma (90 miles) is observed to be two days. Calls for water on the Lower River are generally made when flows at Dutton are near 30 cfs. Travel times from Dutton to Loma during lower flow conditions (about 30 cfs at Dutton) can range from 5 to 12 days based on observations and gaging records. The key factor, appears to be no-flow conditions at Loma. Prolonged dry conditions at Loma can delay travel time significantly because the channel must be re-wetted.

Since the volume of flow appears to be the dominate factor in travel time. The DNRC created a regression equation[8] using velocity and discharge data from manual discharge measurements made on

[8] See Appendix for more information of the regression equation.

the Lower Teton during the TWS. Table 2 shows estimated travel times that can be used by water commissioners to forecast the arrival of called water.

Discharge (Cfs)	Highway 221 to USGS gage at Dutton (Days)	USGS gage at Dutton to Buck Bridge (Days)	Buck Bridge to Loma (Days)
5	10.0	6.0	4.2
10	8.6	5.2	3.6
20	6.8	4.1	2.9
30	5.6	3.4	2.4
40	4.8	2.9	2.0
50	4.3	2.6	1.8
100	2.8	1.7	1.2
Distance	**88 miles**	**53 Miles**	**37 Miles**

Table2: Estimated travel times based on the DNRC regression equation.

Target Flows

The target flow at the USGS Dutton Gage is set at a rate that is substantially larger than the stock rights to account for losses (ET, evaporation and seepage) over the 90 mile stretch of the Teton River below the gage. Based on 2017 data, a target flow rate of 27 cfs at the Dutton gage provides sufficient water to meet stock demands (and any irrigation rights that may be in priority) for the Lower River and will keep the channel wet at the Loma USGS gage. When flow dropped below 27cfs at the Dutton gage on August 19th, 2017, flow at Loma quickly dissipated to no-flow conditions on August 31st.

Wet conditions at Loma are important for maintaining stable and predictable water delivery on the Lower Teton River. Once non-flow conditions start at Loma it has been observed to quickly migrate upstream, creating a situation where the channel must be rewetted before water delivery can begin.

Maintaining suitable target flows to satisfy senior stock rights on the Lower Teton River could:

- Reduce the need for a call for water later in the irrigation season. If target flows are not maintained, calls for water to meet senior stock rights would likely need to be met by reductions in irrigation diversions, during the months of July, August, and September when demand is high.
- Prevent dewatering, a call for water on a dry river requires more water and over a longer time to satisfy the call. The travel time for called water from Choteau area can be upwards of 10 days or more depending on the presence of dry sections of river.

During the cooler time periods in August and September flow less than 27 cfs may be sufficient to meet stock demands. Careful observations of flow and weather conditions on the Lower River by the water commissioner will help to adjust target flows at the Dutton Gage.

Lower River Calls for water above the Springhill Reach

Stock water right holders called for water from the Teton River above the Springhill Reach in both 2016 and 2017. Target flows for the Springhill Reach are not specifically designed to satisfy the needs of the Lower Teton Stock rights. However, monitoring efforts in 2017, show that flow in the Lower Teton River is higher when the Springhill Reach is used to deliver water to Choteau area irrigators. The presence of this additional water in the Lower River (especially during July and August) reduces the chance that the Lower River stock users will have to call for water.

The following steps may help commissioners and water users better understand changing conditions on the river and efficiently meet calls:

- The Lower River commissioner should monitor groundwater conditions in the Springhill reach as an early warning to future conditions on the Lower Teton (See Forecasting Changing Groundwater Conditions in the Springhill Reach Pages 7 & 8).
- Lower River stock right holders should try to anticipate their need to call for water based on declining flow conditions as early as possible (7-21 days).
- Initiate communication between commissioners and water users as early as possible to discuss changing flow conditions, expected flow needs, and the lifting of call when water rights are satisfied.

Target Reaches

Dewatering of the lower reaches of the Teton River and its tributaries is common during the summer. Once a Reach is completely dewatered, groundwater elevations in the local alluvial aquifer are lowered. The effects of having to use dry streambeds to convey called water are:

- More water is required to fulfill the call because it takes more water to rewet dry streambeds and recharge shallow alluvial sediments.
- The time to convey called water will be slower due to the rewetting process.

It is expected that maintaining a wet channel at the following locations will allow commissioners to respond more efficiently if a call for water is made from a downstream location:

1. Deep Creek below Highway 287
2. Muddy Creek at Collins Bridge
3. The lowest senior stock right approximately 1 mile above Loma

Maintaining a wet channel will likely require water to be curtailed from one or more water user.

Recommendations for Monitoring Infrastructure

- Scout for potential existing monitoring wells in the Springhill area that can be used to assess groundwater trends.
- Engage the Teton Watershed Group or the Teton Conservation District to:

- Explore funding opportunities to purchase a real-time gage for Upper Spring Creek or the Teton River near Saylor Bridge.
- Drill monitoring wells if an existing well cannot be found.
- Instrument monitoring wells

Target Flow Rationale and Assumptions

See Appendix

Teton Watershed Stream Gages and Reaches