Lolo Creek Pilot Basin Study - Summary

Part I: Hydrology and Water Use 2016 - 2019

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Units of Water Measurement to know:

- A cubic foot per second (labeled cfs or ft^3/s)
  - This is a unit of discharge – a volume (cubic feet) per unit time (seconds), just like gallons per minute.
  - It is the standard measure of stream/river discharge in the US.
  - One cubic foot is approximately the size of a basketball. So, if you were standing next to a stream flowing at 1 cfs, you could imagine one basketball rolling by every second!
  - 1 cubic foot = $7^1/_2$ gallons; 1 cfs = 450 gallons per minute!
- An acre foot (labeled acre-ft)
  - An acre-ft is a unit of volume, like gallons or cubic feet.
  - It is the standard unit of water supply and use in the US.
  - It is the equivalent of 1 acre of land inundated by water 1 ft deep.
  - 1 acre-ft = 325,851 gallons
  - An Olympic sized swimming pool holds about 2 acre-ft of water.

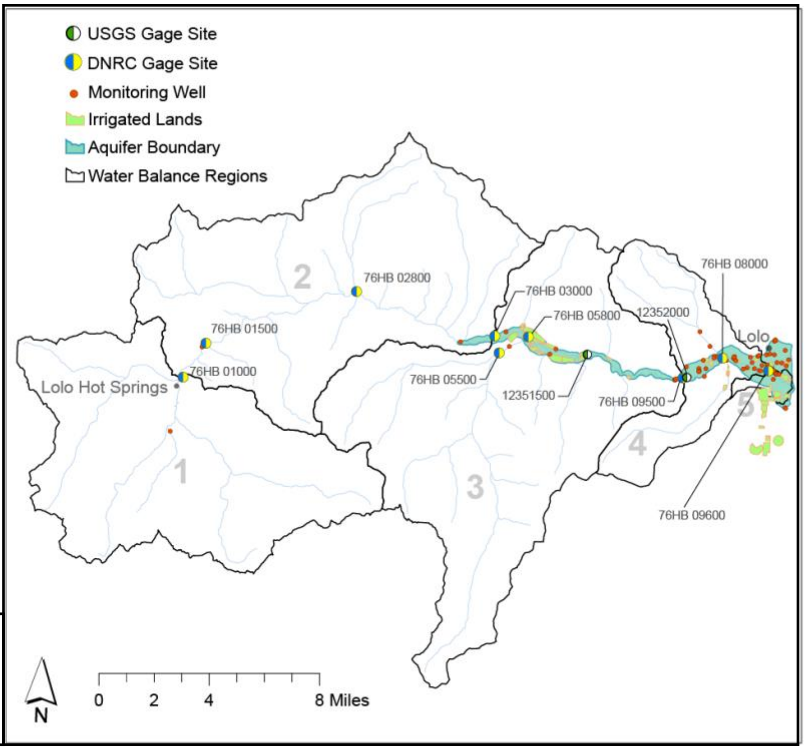
<u>Why not just use something that most people can understand and visualize, like gallons?</u>
As you can see, when working with rivers/streams/lakes/reservoirs, the numbers get big really quick and become more difficult to work with. If you were building a skyscraper you wouldn't want to measure everything in inches!

Project Background

- Lolo Creek provides valuable water resources and habitat for the people, fish, and wildlife of the Lolo Watershed. In years when precipitation is scarce, the creek often dries up throughout the lowest 3 miles (this is called <u>dewatering</u>). This has occurred more frequently over the last 20 years, and growing concerns about it are what led DNRC to conduct this comprehensive water resource investigation.
- The Montana Bureau of Mines and Geology (MBMG) is conducting a complementary study of the groundwater. By pooling resources and data, we can better understand the water fluxes and identify the causes of dewatering.

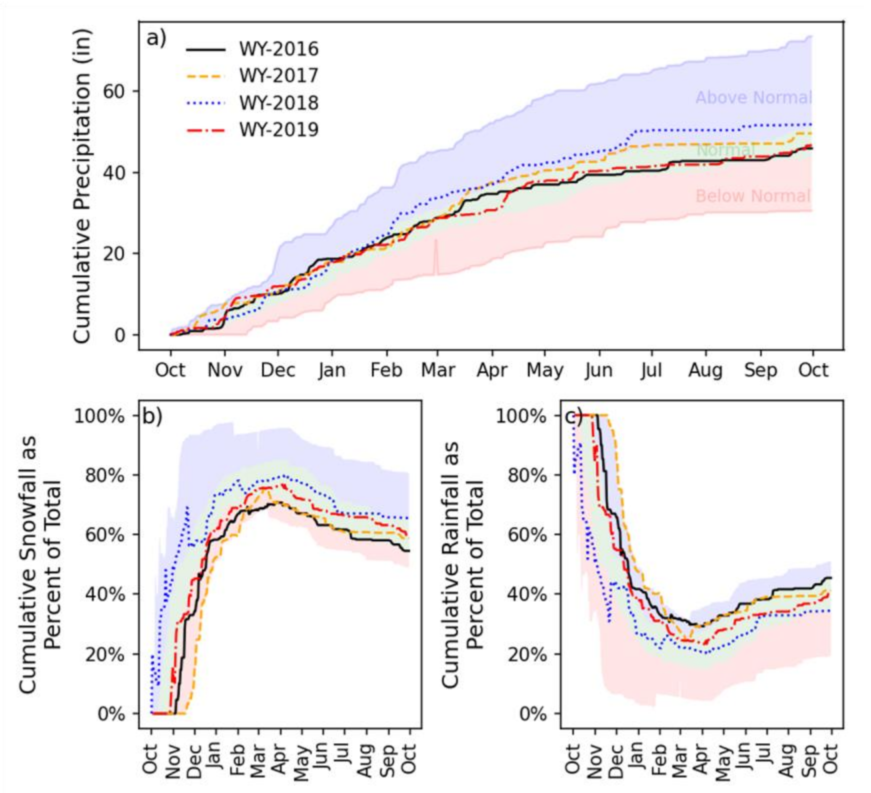
Methods

- Monitored network of surface water (gages) and groundwater (wells) established.
- Estimated inflows and depletions from the creek using streamflow measurements, diversion measurements, groundwater elevations, and satellite derived evapotranspiration.
- Developed a water balance for the watershed.
- Future analyses will offer more detail on how water volume has changed over time and what to anticipate in the future.



Monitoring Site Map
Map of the Lolo Watershed showing monitoring and data collection sites (points) and spatial extents of Water Balance Regions, irrigated lands, and the unconfined-shallow aquifer.

Hydrology of Lolo Creek



Lolo Pass Precipitation Characteristics

Graphs of a) cumulative water year (Oct. 1 of previous year – Sep. 30 of current year) precipitation with lines for each water year in the study period and shading to represent the variation in precipitation based on 1983 to 2020 precipitation; b) cumulative water year snowfall represented as a percentage of the total precipitation; and c) cumulative water year rainfall as a percentage of the total precipitation.

Precipitation

- Total annual precipitation at Lolo Pass has not changed significantly since 1983.
  - Was normal or above normal during all 4 years of the study (based on 1983-2020 statistics).
- In the last decade, the amount of precipitation falling as snow has declined, while the amount of rain has increased.
- During this study, the first snowfall of each year was later than normal (except 2018).
- 2017 set the 40-year record for latest 1st snowfall, 100% of precipitation was rain until late November/early December.

QUIZ!

Which year (2016, 2017, 2018, or 2019) did Lolo Creek produce the most water?

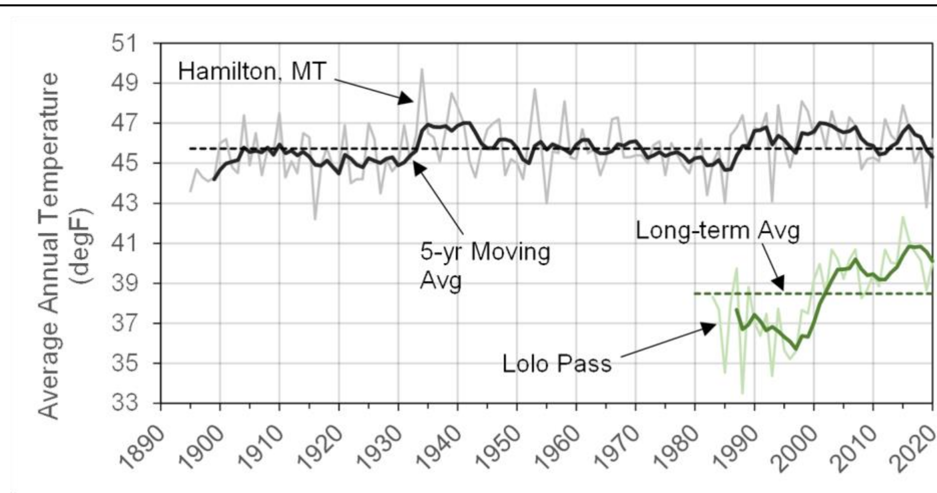
What about the least water?

And largest flood?

- Clearly there is more to streamflow than just precipitation…

Temperature

- Temperature is a VERY IMPORTANT but often overlooked component of streamflow.
- Temperatures in the Bitterroot Valley have been increasing since the 1890s (based on Hamilton weather station).
- Temperature increases are more pronounced at the higher elevation Lolo Pass station.
- Increasing temperatures are responsible for shifting precipitation types.



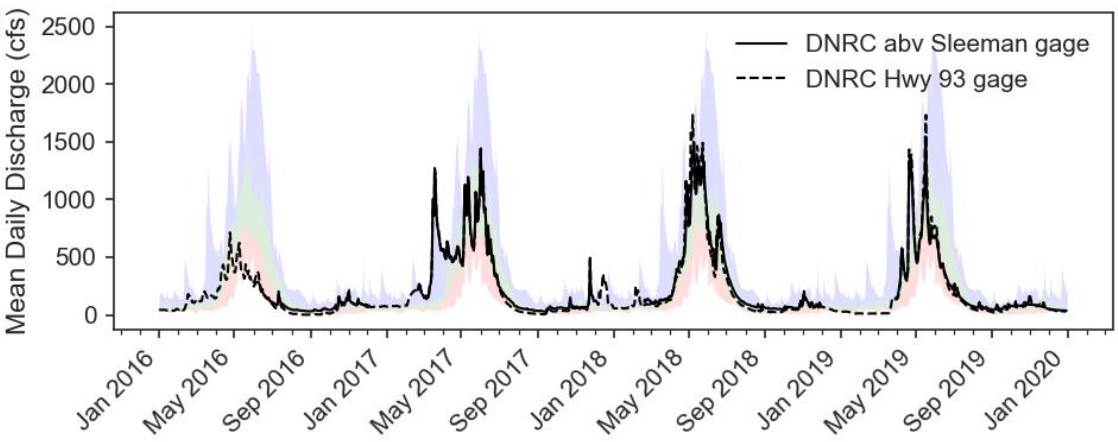
Warming Temperatures in the Bitterroot Basin

Long-term average annual temperature for the Hamilton, MT weather station (1895 – 2020) and the Lolo Pass SNOTEL (1983 -2020). The recent warming since the 1990's is more pronounced at the higher elevation on Lolo Pass.

Snow Storage

- Snow storage is described by the snow water equivalent (or SWE), which is the liquid water content of the snow (this is different from snow depth because the snowpack contains air as well as solid water).
- SWE levels have not substantially changed on Lolo Pass since the 1980s.
- Accumulation of snow has been slower early in the winter and more sporadic throughout the year.
- The rate that snow melts in the spring is increasing

Lolo Creek in December 2016



Lolo Creek Streamflow

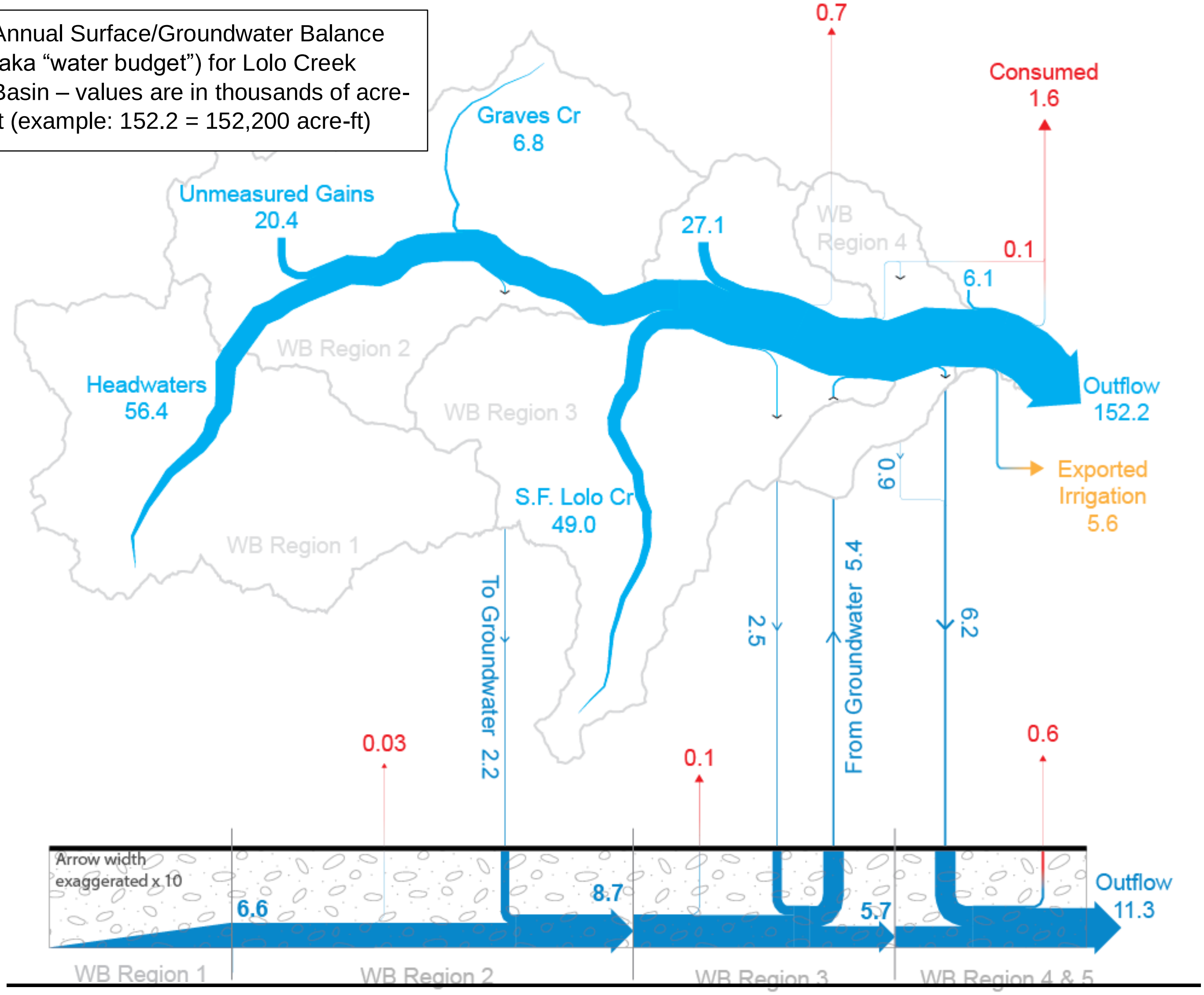
Mean daily discharge at the gage above Sleeman Creek and below Highway 93 for the study period, plotted against statistics for 18-years of flow data (shaded regions).

Streamflow

- The “Flow Regime” of a stream describes how much water there is at different times of the year and how frequently certain flows occur (once a year? Once every 100 years?).
- Lolo Creek (above Sleeman Creek at Mormon Peak Bridge) generally peaks in May.
- 2-yr flood is about 1500 cfs.
- 20-yr flood is about 2200 cfs.
- Spring runoff lasts 100 – 120 days.
- The average annual flow is 257 cfs.
- The average minimum flow is 35 cfs.
- Flow is considered extremely low under 30 cfs.
- All years in the study had earlier than normal peak flows (except 2017).

Water Balance and Water Use

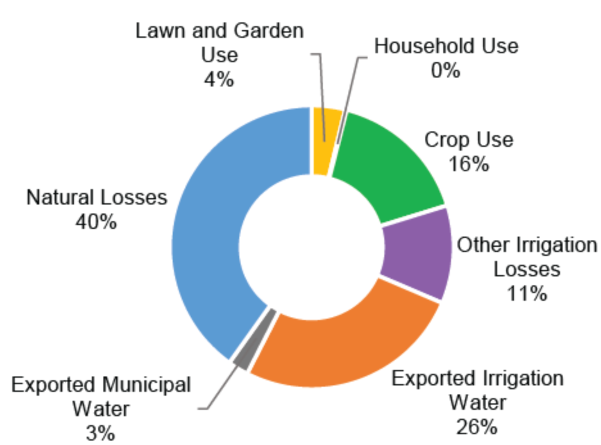
Annual Surface/Groundwater Balance (aka "water budget") for Lolo Creek Basin – values are in thousands of acre-ft (example: 152.2 = 152,200 acre-ft)

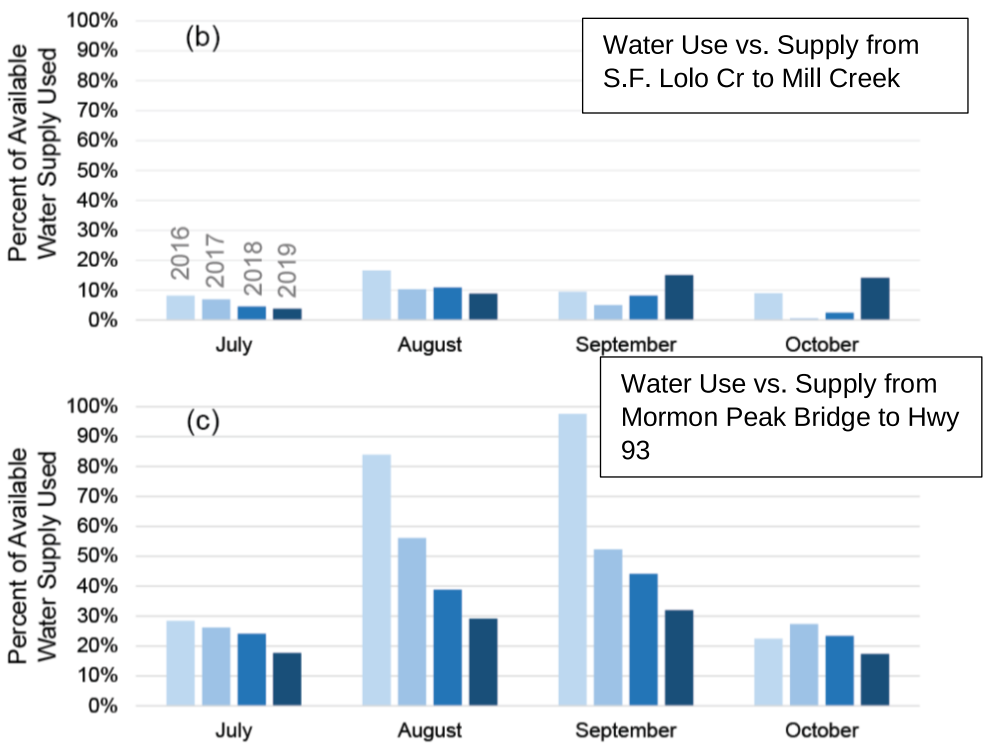


How consumed or exported water is used in Lolo Creek Basin

Table values are in acre-ft

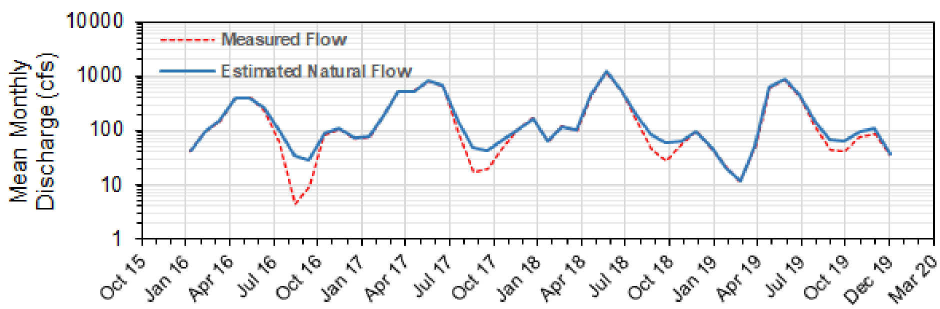
Type of Use	2016	2017	2018	2019	Average
Exported Irrigation Water	2485	3501	3295	3640	3230
Crop Use	2054	2167	1773	2054	2012
Other Irrigation Losses	1625	1946	834	1136	1385
Natural Losses	5594	3503	7788	2971	4964
Lawn and Garden	493	489	432	462	469
Exported Municipal Water	214	425	193	324	289
Household	19	22	19	25	21
TOTAL	12484	12053	14333	10612	12371





Lolo Creek Water Supply vs. Water Use

Monthly water supply versus water use differs by geographic location in the watershed, as well as time of year; however, the use in one area will ultimately affect supply downstream. It is important to note that these data are for monthly variations, but water supply and use can fluctuate on weekly and sometimes even daily time frames such that monthly calculations do not capture shorter periods of over-appropriation.



Lolo Creek Natural Flows

Comparison of measured flows and estimated natural flows at the DNRC Highway 93 stream gage site.

The Big Picture

- Looking at the annual water balance misses the point for Lolo Creek.
- Over appropriated = Water Use exceeds Water Supply.
- Over appropriation depends on location and time of year.
- Natural losses to groundwater are normal for Lolo Creek – can change from year to year.
- Conditions since 2000 have been more favorable for dewatering, likely causing the increase in frequency.
- Would the creek have dried up in 2016 if there was no water use? The data suggests no – but this is not the world we live in.
- Mitigation of dewatering must be voluntary.

What's next??

The Lolo Pilot Basin Study Part I report is currently going through a DNRC internal review and will then be reviewed by MBMG (collaborator). Review should be finished by the end of the summer and then the report and all relevant data will be packaged and available via DNRC's website or in print (by request).

Part II is currently in progress. A finish date for Part II has not been set yet because the modeling involved is being developed jointly with other DNRC water resource projects with varying timelines.

A note about the surface water data used in this study…

This project was made possible in part by DNRC's Stream Gage Program. The Program was initiated in 2015 in response to a State Water Plan recommendation to develop a network of year-round, real-time stream gages and compile and disseminate streamflow data from key locations around the state. The U.S. Geological Survey (USGS) has a nation-wide network of stream gages, including over 200 in Montana, but these gages are more representative of larger rivers. DNRC's program complements the USGS network by providing flow data for smaller streams, tributaries, and canals. Currently, DNRC operates 29 gages throughout the state, and the Hwy 93 gage on Lolo Creek was the 6th gage installed as part of this effort.

DNRC's program offers real-time stream gage and water temperature data that is used for a variety of purposes, including (but not limited to):

- Water rights administration
- Water distribution by water commissioners
- Fisheries management
- Irrigation and water deliveries
- Recreation
- Drought and flood management
- Reservoir operation

Stream flow data from the DNRC and USGS networks can be easily accessed through DNRC's online Stream and Gage Explorer (StAGE, https://gis.dnrc.mt.gov/apps/StAGE/). More information can also be found on the Water Management Bureau's website (http://dnrc.mt.gov/divisions/water/management).

*The funding allocated for the Stream Gage Program is currently not enough to cover the full operation and maintenance costs of the network. At this time, new gages can only be installed if a funding agreement is arranged through a partner agency or group. If you use and like the gage network, please make sure DNRC knows. If you are interested in learning more about cooperative funding agreements with DNRC or if you have other questions about the program, please contact Matt Norberg – 406-444-6041; MNorberg@mt.gov

Real-time gaging station on Lolo Creek at Hwy 93.
Left – Gage house holds equipment that sends data to DNRC database via satellite every 15 minutes.
Below – bubbler at the end of orifice line (shown under water) uses pressurized gas to measure changes in water elevation.