

An Introduction to Snowmelt and Peak Streamflow Comparisons

Rivers in Idaho generally have their highest streamflow of the season (peak flow) as a result of spring snowmelt. In a year with little springtime rain the peak flow is entirely driven by snowmelt, while during a wet spring the peak flow is typically driven by a combination of snowmelt and rainfall. The Idaho Snow Survey has compared historic snow and streamflow data for rivers throughout the state with the goal of finding a relationship that predicts when peak flows are most likely to occur based on the percentage of snow remaining at a specific SNOTEL site.

When on average the peak flow occur when a given SNOTEL site is 50% melted, the relationship is referred to as a “half melt” relationship. Example half relationships include Banner Summit SNOTEL and the Middle Fork of the Salmon River, as well as, Big Creek Summit SNOTEL and the South Fork Salmon River. Another kind of relationship is based on the melt out date (ie when zero snow water remains at a site and the site is snow free), an example would be the Big Lost River at Howell Ranch, which on average, peaks 4 days after Lost-Wood Divide SNOTEL site melts out.

This analyses was updated in 2017. Some are based on data from a few years ago, however the relationships should still be helpful. Spring temperature and precipitation are the driving factors in determining magnitude and timing of snowmelt streamflow peaks. Keep in mind, that spring rains can change snowmelt / streamflow relationships, especially in low snow years when rain generated peaks may exceed snowmelt dominated peak flows or in wet springs like May 2005 when precipitation was 200-300% of average.

Each spring the Idaho Snow Survey updates graphs that show the current snow and streamflow data; these graphs contain a similar year in terms of snow and streamflow to offer additional insight about the size of potential peak flows. The Snow-Stream Comparison graphs are linked from the following webpage...

<http://www.id.nrcs.usda.gov/snow/watersupply/peakflow.html>

What a Snow-Stream relationships tell you?

As an example take the relationship between Big Creek Summit SNOTEL and the South Fork Salmon River, on average the South Fork Salmon River at Krassel Ranger Station peaks when Big Creek Summit SNOTEL is half melted (50% melted). That means if the snow pillow's greatest measurement of the season was 44 inches of snow water, the snow melt driven peak streamflow would be expected on average when the pillow reaches 22 inches of snow water remaining.

This relationship means that it becomes less and less likely that a higher snowmelt driven streamflow peak will occur after Big Creek SNOTEL reaches the point when half of its snow water for the season has melted. It also means that until the snow is half melted there is still plenty of snow water for a significant snowmelt driven peak to occur.

Rain is the wildcard in the equation. The snow-stream melt relationship doesn't reveal anything about the size of the peak that could be generated when a rain event combines with snowmelt. 2010 was an excellent example of this. A rain event with over 2 inches of rain combined with normal snow melt of about 0.6 inch per day and caused a daily peak flow of 6,100 cfs on the SF Salmon (this was one of the highest on record and almost twice the 1993 peak), even though

the maximum snow water at Big Creek in 2010 was 25 inches (~70% of average) vs 1993 when the max snow water was 43 inches (123% of average). What is for sure is that the highest flows almost always occur when a significant rain event falls on a melting snowpack.

Snow to Flow Relationships from 2017 Study with Boise State University, Kara Ferguson

Panhandle / Northern Idaho Region

MOYIE RIVER AND HAWKINS LAKE SNOTEL SITE

On average, peak streamflow for the Moyie River at Eastport, Idaho occurs when Hawkins Lake SNOTEL is between **14 and 29%** melted based on 42 years of data.

Summary of years using only "snowmelt peak" and categorized by max SWE magnitude.

| Max SWE Category | Max SWE Magnitude (inches) | Number of Years in Analysis | Average percent melted at time of peak streamflow |
|----------------------|----------------------------|-----------------------------|---|
| Below average | <24 | 10 | 29 |
| Average | 23 – 36 | 20 | 17 |
| Above average | >35 | 12 | 14 |

The average percent melted for the full 47 year period of record is 16% melted.

Clearwater River Basin

SELWAY RIVER AND TWIN LAKES SNOTEL SITE

On average, peak streamflow for the Selway River near Lowell, Idaho occurs when Twin Lakes SNOTEL is between **26 and 33%** melted.

Summary of all years by max SWE magnitude

| Max SWE Category | Range of Max SWE Magnitude (inches) | Number of Years in Analysis | Average percent melted at time of peak streamflow |
|----------------------|-------------------------------------|-----------------------------|---|
| Below average | <35 | 11 | 33 |
| Average | 34 – 49 | 25 | 33 |
| Above average | >48 | 12 | 26 |

Note - this analysis uses all years available and did not eliminate potential non-snowmelt peaks

The average percent melted for the full 48-year period of record is 33% melted.

LOCSHA RIVER AND LOLO PASS SNOTEL

On average, peak streamflow for the Lochsa River near Lowell, Idaho occurs when Lolo Pass SNOTEL is between **55 and 80%** melted.

Summary of years using only "snowmelt peak" and categorized by max SWE magnitude.

| Max SWE Category | Max SWE Magnitude (inches) | Number of Years in Analysis | Average percent melted at time of peak streamflow |
|----------------------|----------------------------|-----------------------------|---|
| Below average | <22 | 7 | 78 |
| Average | 21 – 34 | 13 | 80 |
| Above average | >33 | 7 | 55 |

The average percent melted for the full 32-year period of record is 77% melted.

Salmon River Basin

MF SALMON RIVER AND BANNER SUMMIT SNOTEL SITE

Discharge Data Years used in analysis: 1981, 1999 - 2016

Gage Height Data Years used in analysis: 1982 -1984, 1986, 1988 -1998

Using combined DISCHARGE and GAGE HEIGHT years, on average, peak streamflow for the MF Salmon at MF Lodge near Yellow Pine Idaho occurs when Banner Summit SNOTEL is between **66 and 90%** melted.

Summary of combined DISCHARGE and GAGE HEIGHT years categorized by max SWE magnitude.

| Max SWE Category | Max SWE Magnitude (inches) | Number of Years in Analysis | Average percent melted at time of peak streamflow |
|----------------------|----------------------------|-----------------------------|---|
| Below average | <21 | 9 | 90 |
| Average | 20 – 31 | 16 | 61 |
| Above average | >30 | 9 | 66 |

Note - this analysis uses all years available and did not eliminate potential non-snowmelt peaks

Using DISCHARGE ONLY years, on average, peak streamflow for the MF Salmon at MF Lodge near Yellow Pine Idaho occurs when Banner Summit SNOTEL is between **64 and 81%** melted.

Summary of DISCHARGE ONLY years categorized by max SWE magnitude.

| Max SWE Category | Max SWE Magnitude (inches) | Number of Years in Analysis | MEDIAN percent melted at time of peak streamflow |
|----------------------|----------------------------|-----------------------------|--|
| Below average | <21 | 5 | 81 |
| Average | 20 – 30 | 8 | 71 |
| Above average | >29 | 5 | 64 |

Note - this analysis uses all years available and did not eliminate potential non-snowmelt peaks

SF SALMON RIVER BIG CREEK SNOTEL SITE

On average, peak streamflow for the SF Salmon near Krassel, Idaho occurs when Big Creek Summit SNOTEL is between **44 and 66%** melted.

Summary by max SWE magnitude

| Max SWE Category | Range of Max SWE Magnitude (inches) | Number of Years in Analysis | Average percent melted at time of peak streamflow |
|----------------------|-------------------------------------|-----------------------------|---|
| Below average | <26 | 7 | 66% |
| Average | 25 - 42 | 14 | 51% |
| Above average | >41 | 7 | 44% |

Note - this analysis uses all years available and did not eliminate potential non-snowmelt peaks

The average percent melted for the full 28-year period of record is 53% melted.

Boise River / West Central Idaho Basins

SF BOISE RIVER AND VIENNA MINE SNOTEL SITE

On average, peak streamflow for the SF Boise River near Featherville, Idaho occurs when Vienna Mine SNOTEL is between **13 and 35%** melted.

Summary by max SWE magnitude

| Max SWE Category | Max SWE Magnitude (inches) | Number of Years in Analysis | Average percent melted at time of peak streamflow |
|----------------------|----------------------------|-----------------------------|---|
| Below average | <28 | 8 | 35 |
| Average | 27 - 42 | 17 | 34 |
| Above average | >41 | 8 | 13 |

Note - this analysis uses all years available and did not eliminate potential non-snowmelt peaks

The average percent melted for the full 33-year period of record is 29% melted.

NORTH AND MIDDLE FORKS BOISE RIVERS ATLANTA SUMMIT SNOTEL

On average, peak streamflow for the Boise River near Twin Springs, Idaho occurs when Atlanta Summit SNOTEL is between **22 and 62%** melted.

Summary by max SWE magnitude

| Max SWE Category | Max SWE Magnitude (inches) | Number of Years in Analysis | Average percent melted at time of peak streamflow |
|----------------------|----------------------------|-----------------------------|---|
| Below average | <23 | 8 | 62 |
| Average | 22 - 38 | 17 | 43 |
| Above average | >37 | 8 | 22 |

Note - this analysis uses all years available and did not eliminate potential non-snowmelt peaks, however, elimination of non-snowmelt peaks did not change the average percent melted

The average percent melted for the full 33-year period of record is 45% melted.

Payette Lake Inflow, on average, peaks:

9 days after meltout at **Bear Basin**,
 6 days after half-melt at **Secesh Summit**, or
 8 days before Secesh Summit melts out.
 This analysis is based on years 1981-1987.

Wood and Lost River Basins

BIG LOST RIVER AND LOST-WOOD SNOTEL SITE

In 22 of 33 years the peak streamflow occurred after Lost Wood had completely melted out.

On average, peak streamflow for the Big Lost River at Howell Ranch near Chilly, Idaho occurs from **1 day before to 7 days after** Lost-Wood SNOTEL is completely melted out.

Summary by max SWE magnitude

| Max SWE Category | Max SWE Magnitude (inches) | Number of Years in Analysis | Average number of days from melt-out peak streamflow occurs |
|----------------------|----------------------------|-----------------------------|---|
| Below average | <14 | 8 | 7 DAYS AFTER |
| Average | 13 - 26 | 17 | 0 DAYS |
| Above average | >25 | 8 | 1 DAY BEFORE |

Note - this analysis uses all years available and did not eliminate potential non-snowmelt peaks

The average for the full 33-year period is 2 days after Lost-Wood SNOTEL has completely melted out.

BIG LOST RIVER AND SMILEY MTN SNOTEL SITE

On average, the Big Lost River at Howell Ranch near Chilly, Idaho peak streamflow occurs when Smiley Mtn SNOTEL is ~ 54% melted.

This analysis is based on historical data from WY 2002 - 2015. Due to the short period of record summarizing by SWE magnitude was not investigated.

BIG WOOD RIVER AND VIENNA MINE SNOTEL SITE

On average, the Big Wood River at Hailey, ID (USGS 13139510) peak streamflow occurs when Vienna Mine SNOTEL is 27 - 47% melted.

This analysis is based on historical data from WY 1982-1983, 1985-2015.

Summary by max SWE magnitude

| Max SWE Category | Max SWE Magnitude (inches) | Average percent melted at time of peak streamflow |
|----------------------|----------------------------|---|
| Below average | <28 | 47 |
| Average | 27 - 43 | 37 |
| Above average | >42 | 27 |

BIG WOOD RIVER AND GALENA SUMMIT SNOTEL SITE

On average, the Big Wood River at Hailey peak streamflow occurs when Galena Summit SNOTEL is 54 - 100% melted.

This analysis is based on historical data from WY 1982-1983, 1983-2015.

Summary by max SWE magnitude

| Max SWE Category | Max SWE Magnitude (inches) | Average percent melted at time of peak streamflow |
|----------------------|----------------------------|---|
| Below average | <17 | 100 |
| Average | 16 - 27 | 76 |
| Above average | <26 | 54 |

BIG WOOD RIVER AND GALENA SNOTEL SITE

On average, the Big Wood River at Hailey peak streamflow occurs when Galena SNOTEL is 64% melted to 10 days after 100% melted.

This analysis is based on historical data from WY 1983-2015.

Summary by max SWE magnitude

| Max SWE Category | Max SWE Magnitude (inches) | Average number of days from melt-out peak streamflow occurs |
|----------------------|----------------------------|---|
| Below average | <13 | 10 DAYS AFTER |
| Average | 12 - 22 | 2 DAYS AFTER |
| Above average | >21 | at ~ 64% MELT-OUT |

Some of the following relationships also reference Degree Days (DD). Degree days is another way to summarize rule of thumb analyses that were performed over the years. The degree day value for is the cumulative total of daily average temperatures that are above zero degree Celsius from a stated date. Below is an example based on counting degree days after March 1st.

| Date | Ave Temperature | Daily Degree Day | Cumulative Degree Days |
|-------------|------------------------|-------------------------|-------------------------------|
| 3/1 | -5 deg C | 0 DD | 0 DD |
| 3/2 | 3 deg C | 3 DD | 3 DD |
| 3/3 | 7 deg C | 7 DD | 10 DD |
| 3/4 | 4 deg C | 4 DD | 14 DD |
| 3/5 | -1 deg C | 0 DD | 14 DD |
| 3/6 | 0 deg C | 0 DD | 14 DD |
| 3/7 | 5 deg C | 5 DD | 19 DD |

Camas Creek near Blaine, on average, peaks:

1 day before Soldier R.S. swe reaches half melt,
 51 Degree Days (DD) after Feb 1 at Soldier R.S.,
 36 DD after peak SWE at Soldier R.S.,

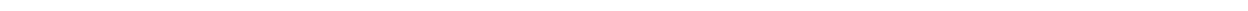
Big Wood River at Hailey, on AVERAGE, peaks

8 days before **Vienna Mine** swe reaches half melt,
 134 Degree Days (DD) after Feb 1 at Vienna Mine,
 96 DD after peak SWE at Vienna Mine,
 9 days after **Galena Summit** reaches half melt,
 4 days before Galena Summit melts out,
 127 DD after Feb 1 at Galena Summit,
 120 DD after peak SWE at Galena Summit.

Snowmelt / peak streamflow relationships for the Big Wood River were developed in conjunction with its reservoir operating guides.

General Observations for Big Wood River:

- Boise high temperatures of 70-75 degrees F for several (days 5-7 days?) days will initiate significant rise in streams.
- Boise high temperatures of 80+ degrees F (for several days?) will probably cause streamflow peak assuming Galena Summit still has some snow.
- If Galena Summit has snow and temperatures are less than 80 degrees F, remaining snow can sustain flows of 4,000 cfs.



Upper Snake Basins

TETON RIVER AND PHILLIPS BENCH SNOTEL SITE

On average, peak streamflow for the Teton River above Leigh Creek near Driggs, Idaho occurs zero to 5 days AFTER Phillips Bench SNOTEL has completely melted out.

Summary of years using only "snowmelt peak" and categorized by max SWE magnitude.

| Max SWE Category | Max SWE Magnitude (inches) | Number of Years in Analysis | Average number of days AFTER melt-out peak streamflow occurs |
|----------------------|----------------------------|-----------------------------|--|
| Below average | 17 – 22 | 7 | 5 |
| Average | 21 – 37 | 17 | 2 |
| Above average | >36 | 9 | 0 |

The average using the 33-years of “snowmelt peaks” is 2 days after Phillips Bench SNOTEL has completely melted out.

TETON RIVER AND GRAND TARGHEE SNOTEL SITE

On average, peak streamflow for the Teton River above Leigh Creek near Driggs, Idaho occurs when Grand Targhee SNOTEL is 50% melted (half-melt).

Based on data from WY 2008 to 2016

2007 was excluded from analysis due to peak streamflow occurring in mid-March ~45 days before maximum SWE

Grand Targhee SNOTEL was installed in 2007. Due to minimal number of years of data available analysis by magnitude of max SWE was not possible.

Southside Snake River / Southern Idaho Basins

OWYHEE BASIN AND MUD FLAT SNOTEL SITE

On average, peak streamflow for the Owyhee River near Rome, Oregon occurs when Mud Flat SNOTEL is between 14 and 30% melted.

The Owyhee basin is heavily influenced by precipitation events which, in many years, are the dominate source of peak streamflow.

For this analysis, only 22 of 32 years were considered snowmelt peaks. Summary of years using only "snowmelt peak" and categorized by max SWE magnitude.

| Max SWE Category | Max SWE Magnitude (inches) | Number of Years in Analysis | Average percent melted at time of peak streamflow |
|----------------------|----------------------------|-----------------------------|---|
| Below average | <5 | 4 | 25 |
| Average | 5 – 10 | 12 | 30 |
| Above average | >9 | 6 | 14 |

The average percent melted for the full 32-year period of record is 30% melted.

OWYHEE BASIN AND SOUTH MTN SNOTEL SITE

On average, peak streamflow for the Owyhee River near Rome, Oregon occurs when South Mtn SNOTEL is approximately 15% melted.

The Owyhee basin is heavily influenced by precipitation events which, in many years, are the dominate source of peak streamflow.

For this analysis, only 17 of 35 years were used to determine the relationship between snowmelt and streamflow. Six of the 17 years, peak streamflow occurred before South Mtn SNOTEL reached max accumulation.

Due to the smaller number of years used in this analysis and the nature of the snowmelt-streamflow relationship, use of averages by peak SWE level is not advised.

Because of the influence of rain on runoff events in the Owyhe Basin, the snowmelt-streamflow relationship between the Owyhee River near Rome stream gage and South Mtn SNOTEL is a weak relationship and should be used with caution.

Salmon Falls Creek and Magic Mountain SNOTEL SITE

On average, the Salmon Falls Creek near San Jacinto, NV peak streamflow occurs when Magic Mountain SNOTEL is approximately 62% melted.

Summary by magnitude MAX SWE

| Max SWE Category | Max SWE Magnitude (inches) | Number of Years in Analysis | Average percent melted at time of peak streamflow |
|----------------------|----------------------------|-----------------------------|---|
| Below average | <16 | 9 | 98 |
| Average | 15 – 23 | 18 | 61 |
| Above average | >22 | 8 | 41 |

The average percent melted for the full 35-year period of record is 62% melted.

Salmon Falls Creek and Pole Creek SNOTEL SITE

On average, the Salmon Falls Creek near San Jacinto, NV peak streamflow occurs when Pole Creek RS SNOTEL is approximately 20% melted.

Summary by magnitude MAX SWE

| Max SWE Category | Max SWE Magnitude (inches) | Number of Years in Analysis | Average percent melted at time of peak streamflow |
|----------------------|----------------------------|-----------------------------|---|
| Below average | <19 | 9 | 60 |
| Average | 18 - 26 | 18 | 42 |
| Above average | >25 | 9 | 20 |

The average percent melted for the full 35-year period of record is 20% melted.

Snowmelt / peak streamflow relationships for Salmon Falls Creek were developed in conjunction with its reservoir operating guides.

Other Key Indicators

- Higher streamflow peaks occur in the range of 1-2 weeks after the peak at **Pole Creek SNOTEL site**.
 - Higher peaks tend to occur in years when the peak SWE at **Magic Mountain and Pole Creek SNOTEL sites** are coincident or close in time. This is a result of the mid and high elevation snowpacks melting at the same time.
 - Streamflows peaks follow jumps in temperatures at the SNOTEL sites in the basin with higher peaks occurring within a week of larger jumps in temperature. In 1993, an increase of about 25 degrees F in 4 or 5 days in early to mid-May produced the streamflow peak 4 days later.
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Bruneau River and Bear Creek SNOTEL Site

On average, the Bruneau River near Hot Springs, Idaho peak streamflow occurs when Magic Mountain SNOTEL is approximately 66% melted.

Summary by magnitude MAX SWE

| Max SWE Category | Max SWE Magnitude (inches) | Number of Years in Analysis | Average percent melted at time of peak streamflow |
|----------------------|----------------------------|-----------------------------|---|
| Below average | <17 | 9 | 100 |
| Average | 16 – 27 | 17 | 64 |
| Above average | >26 | 9 | 31 |

The average percent melted for the full 36-year period of record is 66% melted.

Bruneau River

General Observations based on **Bear Creek SNOTEL site**:

- Peak usually occurs somewhere between beginning of melt and half melt of Bear Creek SNOTEL site, except in years with below to well below normal snow when there was no real snowmelt streamflow peak.
- Bruneau River at Hot Springs gage is generally responsive to changes in snow melt rates.
- Minor streamflow peaks can occur due to pre-melt rain events in the basin.
- Magnitude of peak depends upon:
 - 1) delay of onset of melt,
 - 2) magnitude of snowpack
- Bear Creek usually needs a peak of about 20 inches of snow water to have an adequate runoff season or wet spring for boating. Average April 1 snow water content is 22.4 inches.
