Upper Salmon Basin
Hydrologic Monitoring and Analyses II

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OBJECTIVES

The following objectives were copied from the research proposal submitted to the Idaho Pacific Coastal Salmon Recovery Fund (2022, Round 25). All modifications to tasks, as well as the degree to which each task was completed, are detailed in the subsequent results section.

Data Collection

Task 1: Stream Gaging

Streamflow data has been and will continue to be critical for project planning and evaluation in the Upper Salmon Basin. The current streamflow monitoring network was created in 2005 after reviewing the locations of mission-critical streamflow data with the Upper Salmon Basin Watershed Program (USBWP) Technical Team and collaborators. The number and locations of gages have changed over time, as IDWR regularly adjusts the network to best suit the needs of USBWP and collaborators. Since January 1, 2022, IDWR has managed sixteen stream gages using PCSRF funds. Each gage informs potential for fish passage, habitat health, and/or LRBM calibration. As such, these gages should continue to be operated through this project barring any requests for changes by the USBWP Tech Team. All data is made available at https://research.idwr.idaho.gov/apps/hydrologic/aquainfo/Home/Data#!/. Data from the most recent water year (October 1 through September 30) should be considered preliminary until December 31 unless otherwise stated, while all historical data can be considered finalized.

Task 2: Groundwater Level Measurements

A groundwater level monitoring network of 21 wells was established in May 2011 based on review of the water level monitoring efforts conducted in the late 1990s by Spinazola (1998). Until May 2015, continuous water level measurements were recorded using data loggers in nine wells and biweekly manual measurements were made in the additional 12 wells. In May 2015, the network was expanded to 41 wells; 24 continuously monitored by IDWR and 17 manually measured biweekly by Water District 74 (WD74) through a subcontract.

In 2022, IDWR discontinued the 17 manually measured wells, but continued continuously monitoring water levels at 23 wells. IDWR proposes that this portion of the network be maintained, as these wells contain data loggers that can continue to provide valuable data for years to come. Many of these same wells were also monitored from 1995 through 1998 and can thus provide valuable information about longer term groundwater level trends. A long-term groundwater level dataset is also needed to understand the groundwater (and surface water) impacts of climate change, drought events, flooding events, etc. Manual measurements will be taken, and data will be downloaded on a bi-annual basis. All new data will be uploaded to the public groundwater level database by December 31 (https://idwr-groundwater-data.idaho.gov/applications/public.html?publicuser=public#waterdata/stationoverview). More recent data can be made available upon request, and new wells may be added to the network if deemed beneficial by the USBWP Tech Team or other stakeholders.

Task 3: Soil Moisture Tension Measurements

From 2014 to present, eight soil moisture monitoring sites, each containing sensors at multiple depths, were installed to continuously monitor soil moisture storage and to better characterize infiltration and groundwater recharge in the basin. Six sites were installed in agricultural fields where irrigation was changed from flooding to sprinkler irrigation. In these locations, the soil moisture data allows IDWR to evaluate the hydrologic effects of changes to irrigation practice. The seventh and eighth sites were placed adjacent to Hawley Creek, next to a series of beaver dam analogues (BDAs) installed as part of a salmonid habitat improvement project. At these locations, the soil moisture sensors allow IDWR to assess the hydrologic impact of BDAs.

Four soil moisture sites are still operational today, two in an agricultural field that has converted from flood to sprinkler, and two adjacent to the Hawley Creek BDAs. Data is collected on a bi-annual basis and should continue to be collected through this project, as the changes made to these systems may slowly change soil water dynamics at these locations. The data also provides useful information about infiltration following snowmelt and rain events. IDWR will post the soil moisture data to the project website by December 31 on an annual basis (https://idwr.idaho.gov/water-data/projects/upper-salmon/references/). More recent data is also available upon request.

Task 4: Surface Water Quality Measurements

The impetus for IDWR to begin collecting surface water quality data was that Idaho IDEQ concluded that several reaches of the Lemhi River and its major tributaries contain “Impaired Waters”, with listed pollutants being temperature, sedimentation/siltation, fecal coliform, and nutrients (IDEQ, 1999; 2012). Furthermore, limiting factors to salmonid habitat suitability include elevated summer water temperatures and winter freezing, as well as excess fine sediment (USBWP, 2019; Mike Edmonson, personal communication, 8/7/2019). Additional water quality metrics of concern include pH and dissolved oxygen (DO), as unsuitable concentrations of H+ or DO can result in diminished production, or even mortality of salmonids (Carter, 2008). However, despite these concerns, there were no long-term, coordinated water quality monitoring programs in the basin as of late 2019 (Todd Blythe, personal communication, 9/11/2019).

IDWR established a surface water quality monitoring network in 2020 and has continued monitoring through 2022. Water temperature sensors were deployed, and continuous surface water temperature data was collected at all IDWR managed gages in the Upper Salmon Basin. In addition, the Lemhi River, its return flows, and Lemhi River tributaries were analyzed using multiparameter water quality sondes that record pH, DO, turbidity, specific conductivity, temperature, etc. IDWR recommends additional water quality assessment as part of a long-term monitoring program. Such a program would improve our understanding of water quality trends and help project managers to better mitigate water quality issues in the basin.

Continuous Surface Water Temperature Data:

All IDWR managed gages in the Upper Salmon Basin (this project and the Water Transactions Programs led by Amy Cassel) were outfitted with continuously-recording temperature sensors by mid-2021. It is recommended that this data collection continue through this project. All data will be uploaded to the project website (https://idwr.idaho.gov/water-data/projects/upper-salmon/references/) annually and more recent data can be made available upon request. Water temperature sensors may be deployed at additional locations if requested by members of the USBWP Tech Team or other stakeholders.

Data collected thus far shows that temperatures in many reaches of the Lemhi River are above the optimal salmon spawning temperatures of 54 - 59°F during the summer, and some stretches of the fish-bearing tributaries become warmer than the Lemhi River in the summer and freeze over in the winter. Further data collection would inform efforts to provide more suitable temperatures for salmonids, in addition to aiding predictions regarding temperature impacts of changes to land use, water use, and climate. The impacts of drought and flood periods can also be characterized. As such, a long-term water temperature monitoring network should prove valuable information to managers of both habitat projects and water resources.

Hydrologic Modeling

IDWR has been responsible for developing, maintaining, and running the Lemhi River Basin Model (LRBM) for hydrologic analyses and predictions from 2008 to present. The model has included the entire Lemhi River Basin since 2013 and is regularly updated and recalibrated with new data and hydrologic information to reflect the current state of the basin. Under this task, the LRBM will be updated with new input data and any changes to irrigation practices or diversions. All hydrologic modeling activities are and will continue to be performed by IDWR with assistance from a Mike Hydro Basin consultant on an as-needed basis. Specific modeling goals are detailed below.

Task 5: LRBM and Associated Tool Updates and Improvements

A) The LRBM Habitat Tool will be updated with recent monitoring data and expanded to include temperature and food supply considerations when evaluating habitat suitability (currently the tool uses only flow and stage information).

B) The LRBM Habitat Tool will be updated using the hydrologic data from the climate projections that were generated during the 2022 project. The tool will be able to be used to visualize salmonid habitat suitability given multiple potential climate futures.

Task 6: LRBM Scenarios

A) The LRBM will be used to estimate the impacts of changes to irrigation practices that occurred from 2004 through 2021 using flood and sprinkler irrigation acreage data from the 2022 study.

B) The LRBM will be used to estimate the impacts of potential climate change scenarios on water usage via irrigation water rights.

C) The LRBM will be used to run scenarios submitted by the USBWP Tech Team. The model output data will then be analyzed to evaluate the efficacy of potential future habitat and water transactions projects.

Task 7: Pahsimeroi River Basin Model

Develop the Pahsimeroi River Basin Model and begin developing tools similar to those that IDWR developed for the Lemhi River Basin.

Hydrologic Analyses

A significant amount of hydrologic data has been collected in the Upper Salmon Basin, and especially within the Lemhi Basin, over the past twenty years. As such, it is important to mine and analyze this data to better characterize the hydrology of the region. Below is a list of projects and analyses (Tasks 8-10) that will be completed in this project, though additional work may be completed if deemed beneficial by the USBWP Tech Team.

Task 8: Intensely monitored study site near the confluence of the Mainstem Lemhi River and Lower Hayden Creek

At the request of the PCSRF Board, IDWR developed a plan to monitor and analyze the hydrogeology near the confluence of the Lemhi River and Hayden Creek in 2022. This site was chosen because several habitat improvement projects are likely to begin (on both the Lemhi River and Hayden Creek) near the confluence over the next few years. The purpose of establishing this site is to characterize the local hydrogeology, sediment transport, and water quality before, during, and after the implementation of these projects.

- Three Stream Gages
    - Hayden Creek (IDWR Streamflow Data Portal)
    - Lemhi River near McFarland (5.7 miles upstream of the confluence). Formerly managed by IDWR, but managed by the USGS from 2022 onward (USGS Data Link)
    - Lemhi River nr Lemhi (five miles downstream of the confluence). Operated by the USGS (USGS Data Link)
- Two Additional Manual Streamflow Measurements taken every six weeks – used to calibrate the LRBM and calculate daily differences in flow between the above stream gages and the locations of the manual measurements
    - Just above proposed habitat improvement work on the Lemhi River
    - Just below habitat improvement work on the Lemhi River
- Four Instrumented Monitoring Wells - Continuous groundwater levels and water temperature within two miles of the confluence (IDWR Groundwater Data Portal). Additional nearby wells will be added if well owner permission is granted.
    - 18N 24E 33ACB1
    - 18N 24E 31ACD1
    - 18N 24E 20ADD1
    - 18N 24E 21BCD1
- Three Water Quality Monitoring Sites - Continuous monitoring of temperature, pH, DO, and turbidity using water quality sondes. Grab Samples collected three times per year and tested for Ammonium as N, Nitrogen Nitrite-Nitrate, Total Phosphorus, Total Coliforms, E. coli, and Suspended Solids.
    - Just above proposed habitat improvement work on the Lemhi River
    - Just below habitat improvement work on the Lemhi River
    - At the mouth of Hayden Creek
- Data collection should continue for at least three to five years after the completion of the habitat improvement projects. Descriptive statistics and trend analyses will then be performed on all collected data in order to characterize the hydrogeologic impacts of the completed work. Changes to hydrogeology will be analyzed in conjunction with changes to habitat suitability (LRBM Habitat Tool) to assess the cumulative changes to the system. This analysis will be coupled with salmonid quantity and life stage data collected by other agencies in an effort to characterize the fish-related benefits of the changes to hydrogeology and habitat suitability.

Task 9: Evaluation of the impacts of the Beaver Dam Analogues on Hawley Creek

A series of beaver dam analogues were installed along Hawley Creek starting in 2017. The goal of this task is to evaluate the effectiveness of the beaver dam analogues (BDAs) at providing quality habitat for salmonids and maintaining stream connectivity to the Lemhi River. IDWR began collecting soil moisture data adjacent to Hawley Creek around that time (see “Soil Moisture Tension Measurements” above), and continues to do so today. IDWR also manages three stream gages along Hawley Creek and one on Eighteenmile Creek just downstream of the confluence with Hawley Creek. Trends in both soil moisture tension and streamflow (since 2017) will be characterized to determine if the BDAs might be impacting local hydrogeology. IDWR also plans to deploy ten or more temperature/light sensors within the stream reach containing BDAs. This data will be coupled with salmonid data collected by other agencies to characterize the benefits of changes to local hydrogeology and habitat.

In 2021 and 2022, both Hawley Creek and Eighteenmile Creek (at the IDWR gage) ran dry, thereby disconnecting Hawley Creek from the Lemhi River. Although this gage has a history of running dry or nearly dry most years, there is concern from local stakeholders that the BDAs have made it less likely for flow from Hawley Creek to reach Eighteenmile Creek and ultimately the Lemhi River. There is a question of where this water is going when Hawley Creek dries up. The potential for a hydrologic tracer study is being evaluated, and will be employed if deemed useful and an opportunity (e.g. a section of Hawley Creek drying up) presents itself.

Task 10: Evaluation of the hydrologic impacts of stream channel migration and changes to irrigation practices in the Pratt Creek Drainage

IDWR began monitoring streamflow, groundwater levels, and soil moisture tension in the Pratt Creek drainage in 2016 to 2017. Following installation of this monitoring network, irrigation of the local agricultural fields was changed from flood to sprinkler irrigation (prior to 2017 irrigation season) and a 3,000 foot section of the Pratt Creek stream channel was migrated as part of a habitat improvement project. After five or more years of data collection at each of these sites, IDWR proposes that the data be analyzed to characterize the impacts of these changes. Statistical analyses will be performed to test for hydrologic changes following the changes to irrigation practices and the stream channel, and trend analyses will be performed to test if streamflow, groundwater levels, or soil moisture tension has been changing over the period of record.

Task 11: Trends in Streamflow and Groundwater Levels

In 2022, IDWR characterized streamflow trends at all Upper Salmon Basin gages with ten or more years of data using Mann Kendall Trend Tests. When this data was presented to the USBWP Advisory Committee, it led to the following questions: 1) What are the impacts of the drought year in 2021 on trend analyses (the analysis was only conducted through 2020)? 2) What are the trends in natural streamflow (e.g., if no diversions were present)? 3) Were there any trends in seasonality (e.g. is peak flow later in the year now than it was earlier in the period of record)? IDWR will answer these questions by conducting additional trend analyses and reporting the results.

IDWR also characterized trends in groundwater levels in the 2022 study. Median groundwater level data from 1995 through 1998 was compared to data collected from 2005 through 2021 (varying periods of record). This analysis showed that much of the Upper Lemhi Basin had declining water levels in recent years relative to those in the mid-1990s, the Middle Lemhi Basin had mixed results, and the Lower Lemhi Basin actually had increased water levels at the majority of wells. However, after presenting this data, there were similar questions about drought years (e.g., 2021) and trends in seasonality. There were also questions about the impacts of water right curtailment on wells near diversion ditches or flood irrigated fields. IDWR will perform additional analyses to address these questions in this study.

RESULTS

This project was guided by the objectives outlined in the Pacific Coastal Salmon Recovery Fund (PCSRF) Round 25 proposal submitted to the Idaho Governor's Office of Species Conservation (see Objectives section). Over the course of project implementation, adjustments to data collection and analysis activities were made in response to evolving Upper Salmon Basin Technical Team (Tech Team) priorities and Idaho Department of Water Resources (IDWR) staffing transitions.

Project activities began in July 2023 and continued through January 2025, when the IDWR project hydrogeologist accepted a new position. The IDWR project hydrogeologist position remained vacant until January 2026, requiring adaptive management of monitoring and analysis efforts. During this period, the former project lead continued to manage monitoring and analysis contracts as well as oversee processing and publication of streamflow data. This report documents all relevant work completed during the project, including additions, discontinuations, and deviations from the original proposal.

Task 1 – Streamflow Monitoring Network

IDWR collects streamflow data to support endangered salmonid recovery efforts in the Upper Salmon Basin by informing the planning, implementation, and evaluation of streamflow enhancement and instream habitat improvement projects. These data are also used to calibrate the Lemhi River Basin Model (LRBM), which provides a catchment-scale framework for water resources and coordinating water management actions intended to improve habitat conditions.

As of March 26, 2026, IDWR actively manages or cooperates on 46 stream gages in the Upper Salmon Basin, 13 of which are supported through this project using Pacific Coast Salmon Recovery Fund (PCSRF) funds (Table 1, Figure 1). As a focal area for salmonid habitat improvement efforts, the Lemhi Basin contains 12 of the 13 PCSRF-funded gages (Figure 2). To support basin-wide streamflow and trend analyses presented later in this report, all gages operated by IDWR and the U.S. Geological Survey (USGS) are included in the tables and figures (Table 1, Figure 1 and Figure 2).

All PCSRF-funded gages continuously record stage data using either a pressure transducer or bubbler system. On-site streamflow measurements are collected at each gage approximately once every six weeks, conditions permitting, and during high-flow periods. Streamflow is measured using an acoustic Doppler velocimeter, acoustic Doppler current profiler, or dilution gaging methods. Recorded stage data and streamflow measurements are used to develop stage-discharge rating curves used to compute daily mean streamflow values.

Several adjustments were made to the streamflow monitoring network during the project period to reflect evolving project needs, access constraints, and staffing conditions. The Bohannon Creek (Upper) gage was discontinued in August 2023 due to the loss of private land access permissions. The Big Eightmile Creek (Lower) gage was discontinued in September 2023, as it was no longer needed to calibrate the Lemhi River Basin Model. The Bayhorse Creek gage continues to be maintained by IDWR but was transferred to the Idaho Water Transactions Program (IWTP) in 2025. The Hawley Creek (Middle) and Hawley Creek (Lower) gages were funded through this project from 2023 through October 2025 but were subsequently discontinued in response to shifting Tech Team priorities. In addition, a preexisting gage on the East Fork Salmon River is scheduled to be added to the Pacific Coast Salmon

Recovery Fund network in spring 2026. It is also important to note that eight gages in the Lemhi Basin were not visited between November 2024 and July 2025, resulting in greater uncertainty in computed streamflow during that period.

All PCSRF and other IDWR streamflow data (Table 1, Figure 1) collected through September 30, 2025, have been posted to the web portal (Aqua Info). Data from water year 2025 (October 1, 2024, through September 30, 2025) and earlier are considered finalized, while data from water year 2026 should be considered preliminary until December 31, 2026, unless otherwise specified by IDWR. Additional Upper Salmon Basin streamflow data collected by the USGS can be found in the USGS web portal (NWIS).

Table 1. Upper Salmon Basin streamflow monitoring network

Gage Name	Latitude	Longitude	Data Source	Period of Record
Agency Creek[1]	44.949	-113.568	Aqua Info	2005 - present
Alturas Lake Creek	43.982	-114.846	Aqua Info	2006 - 2015
Bayhorse Creek	44.378	-114.257	Aqua Info	2013 - present
Beaver Creek	43.919	-114.814	Aqua Info	2004 - present
Big Eightmile Creek Lower	44.694	-113.482	Aqua Info	2008 - 2023
Big Eightmile Creek Upper[1]	44.644	-113.529	Aqua Info	2005 - present
Big Hat Creek	44.818	-114.111	Aqua Info	2004 - 2005
Big Springs Creek Lower	44.728	-113.433	Aqua Info	2005 - present
Big Springs Creek Upper[1]	44.711	-113.409	Aqua Info	2008 - present
Big Timber Creek nr Leadore	44.689	-113.37	NWIS	2004 - present
Big Timber Creek Upper[1]	44.614	-113.397	Aqua Info	2005 - present
Bohannon Creek Lower	45.122	-113.732	Aqua Info	2008 - present
Bohannon Creek Upper	45.191	-113.691	Aqua Info	2013 - present
Bruno Creek nr Clayton	44.298	-114.481	NWIS	1971 - present
Canyon Creek	44.691	-113.364	Aqua Info	2008 - 2018, 2020 - present
Canyon Creek bl CC2 Div	44.697	-113.337	Aqua Info	2022 – present
Carmen Creek Lower	45.246	-113.893	Aqua Info	2005 - 2022, 2024 - present
Carmen Creek Upper	45.345	-113.789	Aqua Info	2005 - 2018
Challis Creek Lower	44.569	-114.194	Aqua Info	2005 - 2019
Challis Creek Upper	44.572	-114.305	Aqua Info	2005 - 2019
East Fork Salmon River[1]	44.267	-114.325	Aqua Info	2004 - 2018, 2022 - present
Eighteenmile Creek[1]	44.668	-113.314	Aqua Info	2006 - present
Eighteenmile Creek Mouth	44.683	-113.352	Aqua Info	2008 - 2009
Falls Creek	44.583	-113.766	Aqua Info	2005 - 2007
Fourth of July Creek	44.03	-114.834	Aqua Info	2004 - 2018, 2020 - present
Garden Creek	44.511	-114.203	Aqua Info	2005 - 2007
Goat Creek	44.219	-114.952	Aqua Info	2018 - present
Hawley Creek Lower	44.672	-113.302	Aqua Info	2020 - 2025
Hawley Creek Middle	44.659	-113.216	Aqua Info	2020 - 2025
Hawley Creek Upper[1]	44.667	-113.192	Aqua Info	2008 - present
Hayden Creek[1]	44.87	-113.627	Aqua Info	1997 - present

Gage Name	Latitude	Longitude	Data Source	Period of Record
Herd Creek	44.117	-114.262	Aqua Info	2005 - 2007
Iron Creek	44.888	-113.971	Aqua Info	2006 - 2018, 2020 - present
Kenney Creek	45.027	-113.654	Aqua Info	2004 - 2017, 2020 - present
Knapp Creek Lower	44.368	-115.126	Aqua Info	2023
Lee Creek[1]	44.746	-113.476	Aqua Info	2009 - present
Lemhi River ab Big Springs[1]	44.729	-113.433	Aqua Info	2005 - present
Lemhi River ab Hayden Creek	44.867	-113.625	Aqua Info	2004 - 2009
Lemhi River ab L-63	44.682	-113.356	Aqua Info	2008 - 2019
Lemhi River at Baker	45.098	-113.722	Aqua Info	2004 - 2009
Lemhi River at Cottom ln[1]	44.749	-113.476	Aqua Info	2005 - present
Lemhi River at L-1[1]	45.177	-113.886	Aqua Info	1997 - present
Lemhi River bl L5 Diversion	45.133	-113.799	NWIS	1993 - present
Lemhi River nr McFarland	44.803	-113.566	NWIS	2011 - 2019, 2021 - present
Lemhi River nr Lemhi	44.94	-113.639	NWIS	1938 - 1939, 1955 - 1964, 1967 - present
Little Morgan Creek	44.653	-113.932	Aqua Info	2005 - 2007
Little Springs Creek Lower	44.779	-113.544	Aqua Info	2008 - 2021, 2023 - present
Little Springs Creek Upper	44.773	-113.528	Aqua Info	2008 - 2016
Meadow Creek	44.218	-114.944	Aqua Info	2018 - present
Morgan Creek	44.612	-114.17	Aqua Info	2006 - 2021
Napias Creek bl Arnett Creek	45.206	-114.134	NWIS	1998 - present
North Fork Salmon River	45.406	-113.994	Aqua Info	2005 - 2007
Paasasikwana Naokwaide bl Bruno Ck	44.291	-114.472	NWIS	1975 - present
Pahsimeroi River at Ellis	44.692	-114.047	NWIS	1984 - present
Pahsimeroi at Furey ln	44.526	-113.848	Aqua Info	2004 - 2019
Pahsimeroi River bl P-9	44.597	-113.953	Aqua Info	2005 - 2018, 2020 - present
Panther Creek at Cobalt	45.069	-114.27	NWIS	2011 - present
Patterson Big Springs Lower	44.606	-113.951	Aqua Info	2009
Patterson Big Springs Upper	44.596	-113.938	Aqua Info	2008 - present
Pole Creek	43.909	-114.759	Aqua Info	2005 - 2017, 2020 - present
Pratt Creek	45.078	-113.699	Aqua Info	2017 - present
Salmon River ab East Fork	44.267	-114.327	NWIS	2022 - present
Salmon River at Salmon	45.184	-113.895	NWIS	1912 - 1916, 1919 - present
Salmon River bl Yankee Fork	44.268	-114.733	NWIS	1921 - 1991, 2000 - present
Salmon River nr Obsidian	44.001	-114.833	Aqua Info	2004 - 2009
Salmon River nr Shoup	45.323	-114.44	NWIS	1977 - 1981, 2002 - present
Salmon River nr Stanley	44.257	-114.833	Aqua Info	2004 - 2009
Texas Creek[1]	44.636	-113.323	Aqua Info	2008 - 2013, 2015 - present
Thompson Creek nr Clayton	44.27	-114.517	NWIS	1972 - present
Valley Creek at Stanley	44.223	-114.931	NWIS	1911 - 1913, 1921 - 1972, 1992 - present
Yankee Fork Salmon River nr Clayton	44.279	-114.734	NWIS	1921 - 1948, 2011 - present

[1] Stream gage managed using PCSRF funds as of March 26, 2026

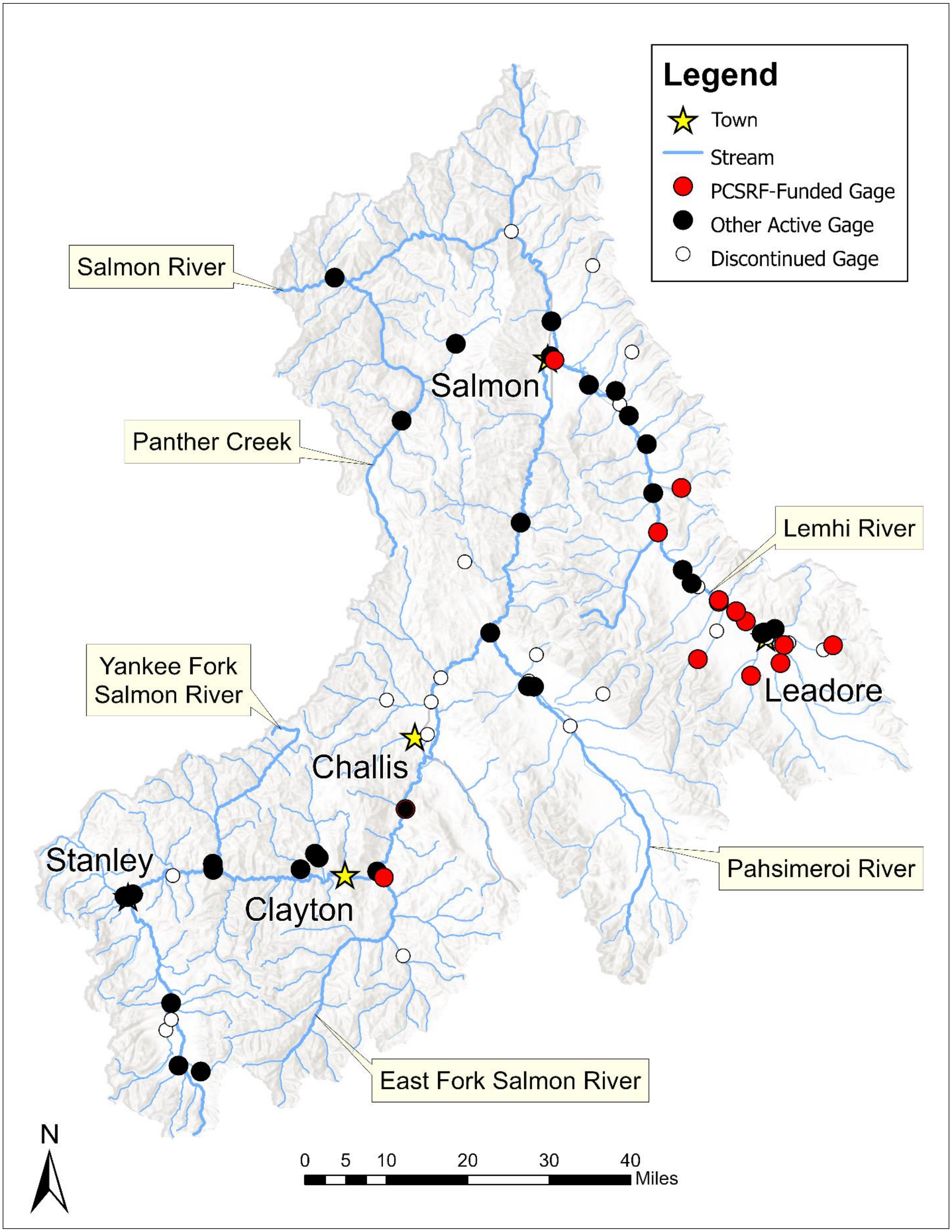


Figure 1. Upper Salmon Basin streamflow monitoring network

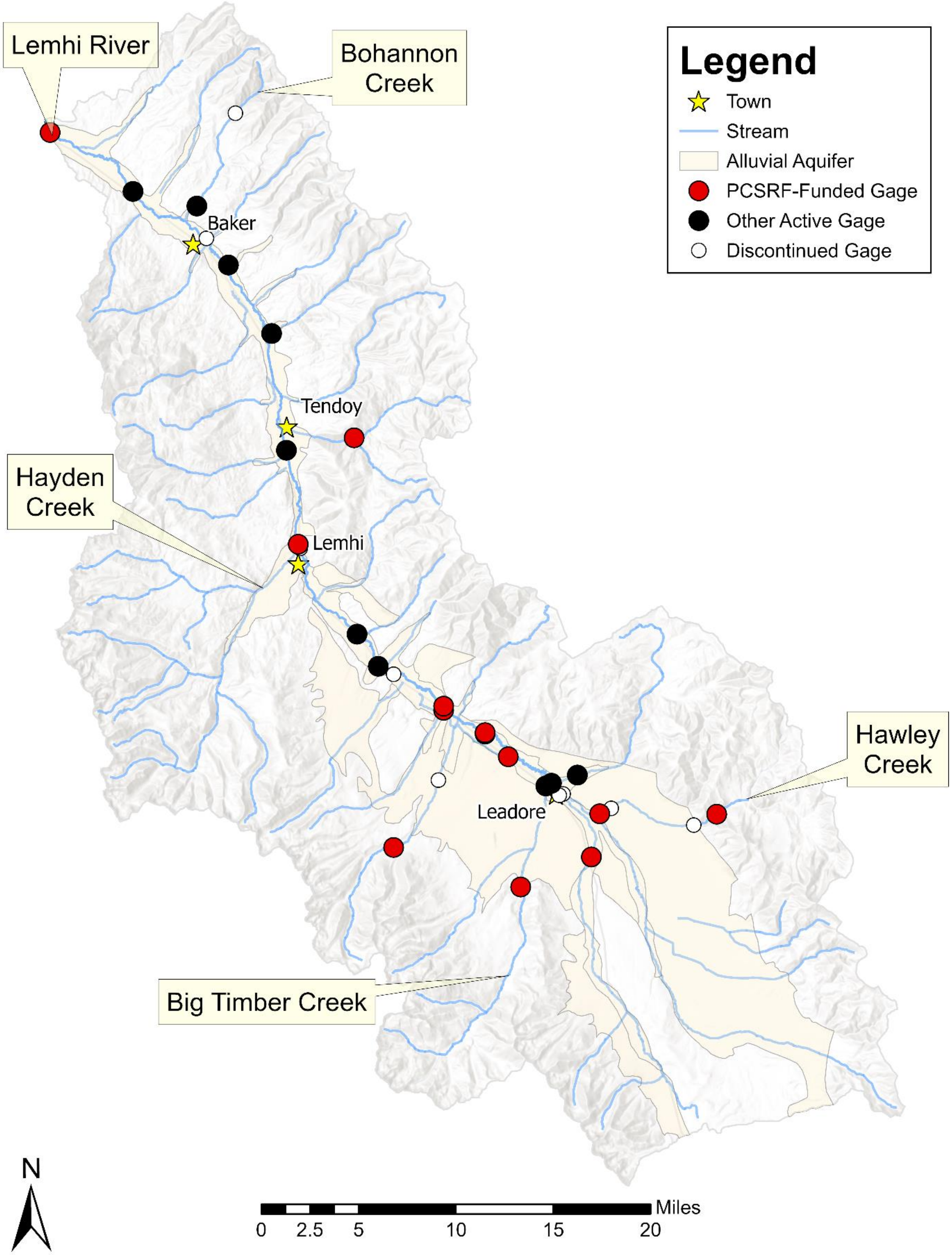


Figure 2. Lemhi Basin streamflow monitoring network

Task 2 – Groundwater Level Monitoring Network

Groundwater level data are collected to evaluate how changes in land use, stream channel conditions, water management practices, and climate affect groundwater and surface water availability in the Upper Salmon Basin. Understanding interactions between groundwater and surface water is particularly important in Idaho, where water resources are subject to conjunctive management. As such, groundwater levels and streamflow data are used to characterize these interactions and to inform planning and development of water management and habitat improvement projects.

The Upper Salmon Basin groundwater level monitoring network currently consists of 23 instrumented wells in the Lemhi Basin (Table 2, Figure 3), as well as one instrumented well and three non-instrumented wells in the Pahsimeroi Basin (Table 2). In the Lemhi Basin, actively monitored wells have periods of record ranging from 9 to 14 years, with select wells also measured biweekly during the 1995–1998 period (Table 2). The 24 total instrumented wells are equipped with non-vented In-Situ Level TROLL data loggers, which continuously record groundwater levels and temperature at a minimum of 12-hour intervals. Groundwater levels at all monitoring wells are also measured semiannually using a calibrated electric tape, typically in the spring and the fall. For instrumented wells, these manual measurements are used to calibrate and maintain the accuracy of the water-level readings collected by the data loggers.

The monitoring wells in the Pahsimeroi Basin were visited during the spring and fall of 2025. Due to the IDWR staffing transition, the monitoring wells in the Lemhi Basin were not visited in 2025. Following the hire of the new PCSRF project lead in January 2026, 19 of the 23 monitoring wells in the Lemhi Basin were visited in January 2026, with plans to visit the remaining wells in spring 2026. Because the Lemhi Basin wells are instrumented, groundwater level data are available for 2025, despite the gap in site visitation. All groundwater level data collected through January 2026 have been posted to the IDWR web portal (Groundwater Data Portal), and all published data should be considered final. Individual hydrographs are also available in Appendix A.

Table 2. IDWR groundwater level monitoring sites within the Upper Salmon Basin. Refer to Appendix A for hydrographs for individual wells.

Well Number	Latitude	Longitude	Well Depth (ft)	Instrumentation	Period of Record	Subbasin[2]
21N 23E 30DAC1[1]	45.118	-113.775	27	Data Logger	2013 - 2025	LL
21N 23E 30ABC1	45.126	-113.779	75	None	2011 - 2021	LL
21N 22E 24DCA1[1]	45.131	-113.797	52	None	2011 - 2021	LL
21N 22E 14CDD1[1]	45.144	-113.823	37	None	2011 - 2021	LL
21N 22E 10CCA1	45.16	-113.848	38	Data Logger	2011 - 2025	LL
21N 22E 10ACD2[1]	45.165	-113.839	45	None	2011 - 2021	LL
21N 22E 09DDB1[1]	45.159	-113.857	34	Data Logger	2011 - 2025	LL
21N 22E 09DAB1	45.164	-113.856	40	None	2011 - 2021	LL
20N 24E 31DDC1	45.013	-113.653	36	Data Logger	2013 - 2025	LL
20N 23E 25DAB1	45.033	-113.673	-	None	2011 - 2021	LL
20N 23E 24CDD1[1]	45.043	-113.68	-	None	2011 - 2021	LL

Well Number	Latitude	Longitude	Well Depth (ft)	Instrumentation	Period of Record	Subbasin[2]
20N 23E 14DDB1[1]	45.058	-113.693	-	Data Logger	2015 - 2025	LL
20N 23E 11DBB2	45.077	-113.698	50	Data Logger	2016 - 2025	LL
20N 23E 11DBB1	45.076	-113.698	46	Data Logger	2016 - 2025	LL
20N 23E 11ADD2	45.079	-113.692	37	Data Logger	2016 - 2025	LL
20N 23E 11ADD1	45.079	-113.692	37	Data Logger	2016 - 2025	LL
20N 23E 10ABA1[1]	45.084	-113.717	-	None	2011 - 2021	LL
20N 23E 03CBA2[1]	45.091	-113.727	142	Data Logger	2011 - 2025	LL
19N 24E 32ADC1[1]	44.934	-113.633	61	Data Logger	2013 - 2025	LL
19N 24E 30AAA2[1]	44.955	-113.65	-	Data Logger	2015 - 2025	LL
19N 24E 29BDA1[1]	44.951	-113.639	-	Data Logger	2015 - 2025	LL
19N 24E 28ABB2[1]	44.953	-113.617	-	None	2011 - 2021	LL
19N 24E 17BBB1[1]	44.983	-113.647	-	None	2011 - 2021	LL
18N 24E 33ACB1[1]	44.834	-113.602	-	Data Logger	2013 - 2025	UL
18N 24E 31ACD1[1]	44.847	-113.65	-	Data Logger	2015 - 2025	UL
18N 24E 28DCC3[1]	44.854	-113.618	-	None	2011 - 2021	UL
18N 24E 21BCD1[1]	44.876	-113.629	45	Data Logger	2011 - 2025	UL
18N 24E 20ADD1	44.877	-113.625	72	Data Logger	2011 - 2025	UL
18N 24E 16BBB1[1]	44.895	-113.628	40	None	2011 - 2021	UL
17N 24E 13CBD1[1]	44.8	-113.556	31	Data Logger	2015 - 2025	UL
17N 24E 04ADC1[1]	44.847	-113.61	34	Data Logger	2015 - 2025	UL
16N 26E 27CCB1	44.684	-113.354	-	Data Logger	2015 - 2025	UL
16N 26E 27CAC1[1]	44.684	-113.349	81	None	2011 - 2021	UL
16N 26E 26DBB1[1]	44.687	-113.323	200	None	2011 - 2021	UL
16N 26E 26CBC1	44.685	-113.333	-	None	2011 - 2021	UL
16N 26E 26ABB1[1]	44.693	-113.323	-	None	2011 - 2021	UL
16N 26E 21CAC1[1]	44.7	-113.367	-	Data Logger	2011 - 2025	UL
16N 26E 21ACA1[1]	44.706	-113.359	-	None	2011 - 2021	UL
16N 26E 20CDD1	44.696	-113.386	60	Data Logger	2013 - 2025	UL
16N 25E 20BDD1[1]	44.703	-113.51	63	Data Logger	2015 - 2021	UL
16N 25E 18BBC1[1]	44.721	-113.538	60	Data Logger	2011 - 2019	UL
16N 25E 03BCC1[1]	44.746	-113.478	42	Data Logger	2011 - 2025	UL
15N 26E 09ADD2[1]	44.645	-113.355	180	None	2015 - 2016	UL
16N 20E 36CAD1	44.672	-114.044	-	None	2024 - 2025	P
14N 22E 35BBD1	44.505	-113.826	249	Data Logger	1987 - 1989, 2003 - 2025	P
13N 23E 35CCB2	44.409	-113.708	102	None	2007, 2010 - 2025	P
12N 23E 03AAD1	44.403	-113.712	128	None	1971 - 2025	P

[1] Data set includes 1995 - 1998 measurements from Donato (1998) study.

[2] LL = Lower Lemhi Subbasin, UL = Upper Lemhi Subbasin, P = Pahsimeroi Basin

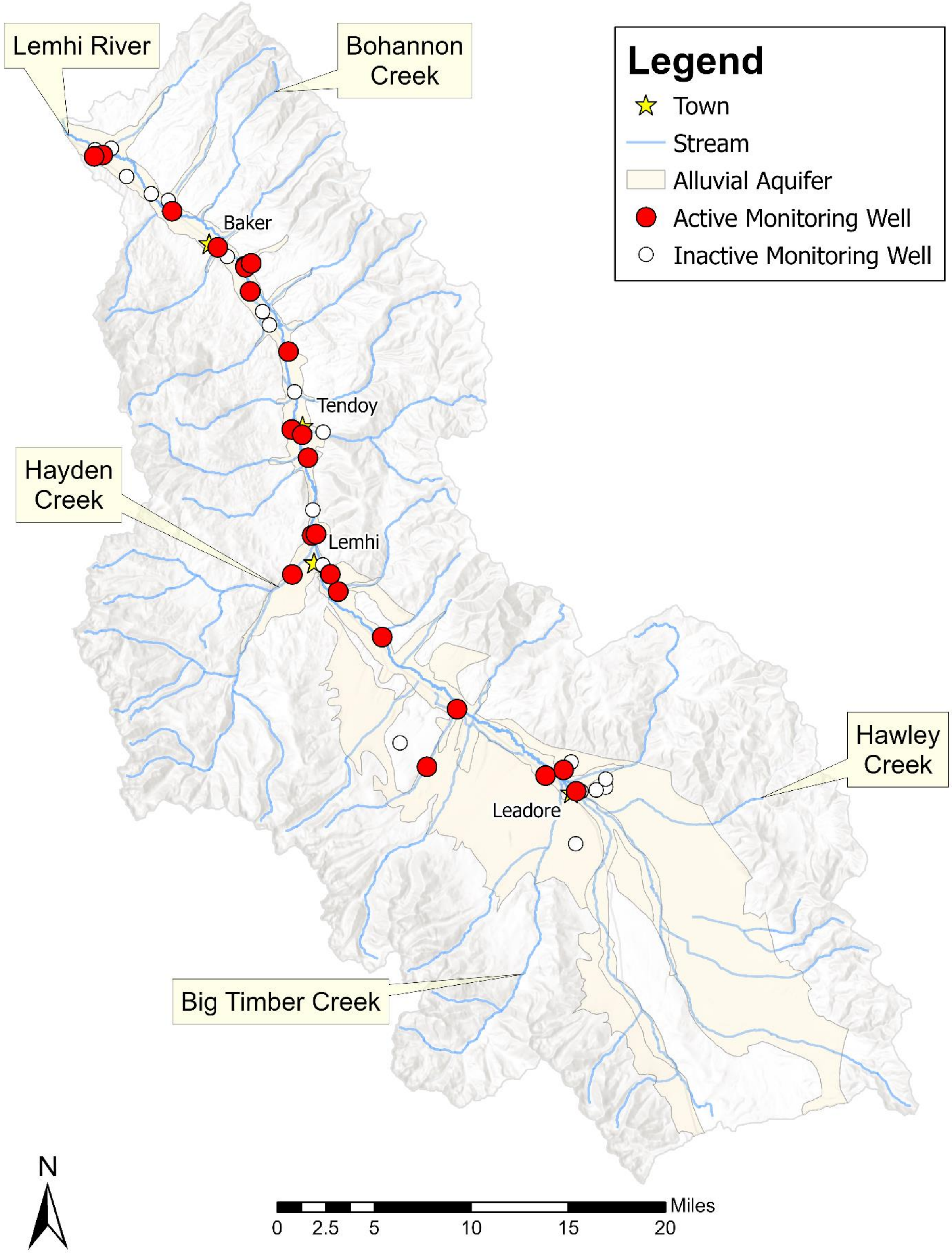


Figure 3. Lemhi Basin groundwater level monitoring network

Task 3 – Soil Water Tension Measurements

Soil water tension data have been collected in the Lemhi Basin to support the evaluation of relative changes to soil water storage and groundwater recharge potential in areas influenced by changes to water use and habitat improvement work. Between 2012 and 2017, IDWR installed soil water tension monitoring stations at eight locations within the Lemhi Basin (Table 3, Figure 4). Each station is equipped with tensiometers at multiple depths within the soil profile. Each tensiometer records soil water tension every two hours. This design supports assessment of relative changes to soil water storage, as well as groundwater recharge potential, with sustained wet or saturated conditions (low tension readings) at greater depths suggesting conditions favorable for recharge.

The Lemhi Basin Soil Water Tension Monitoring Network currently consists of four active monitoring stations (Table 3, Figure 4). Two stations are located adjacent to agricultural fields in the Pratt Creek drainage, and two are located adjacent to former beaver dam analogues that existed along Hawley Creek from 2017 to 2021. The stations in the Pratt Creek drainage (Pratt 1 and Pratt 2) each contain one instrumented soil pit, whereas both stations along Hawley Creek (Hawley BDA4 and Hawley BDA5) include two instrumented soil pits. At each Hawley Creek station, one soil pit is located within the ephemerally inundated portion of the stream channel, and one is located above the streambank. Stations are typically visited annually to download data and perform routine maintenance.

The Hawley Creek sites were last visited in April 2024, and the Pratt Creek sites were last visited in November 2024. The tensiometer batteries typically have a service life of slightly over one year, which likely will result in a data gap beginning in mid-2025. IDWR intends to visit these sites in spring 2026 to download data and perform routine maintenance. All collected soil water tension data will be made available on the IDWR Upper Salmon Basin Hydrologic Project website (https://idwr.idaho.gov/water-data/projects/upper-salmon/references/). In addition, the Upper Salmon Basin Hydrologic Monitoring and Analyses Report (IDWR, 2023) contains an analysis of trends in soil water tension.

Table 3. IDWR soil water tension monitoring network in the Lemhi Basin

Soil Water Tension Site	Latitude	Longitude	Period of Record	Sensor Depths (ft)
Pratt Creek 1	45.083	-113.686	2016 - present	0.5, 1, 2, 3, 4, 5
Pratt Creek 2	45.079	-113.691	2016 - present	0.5, 1, 2, 3, 4, 5
Hawley Creek BDA4	44.658	-113.222	2017 - present	1, 3, 5
Hawley Creek BDA5	44.658	-113.221	2017 - present	1, 3, 5

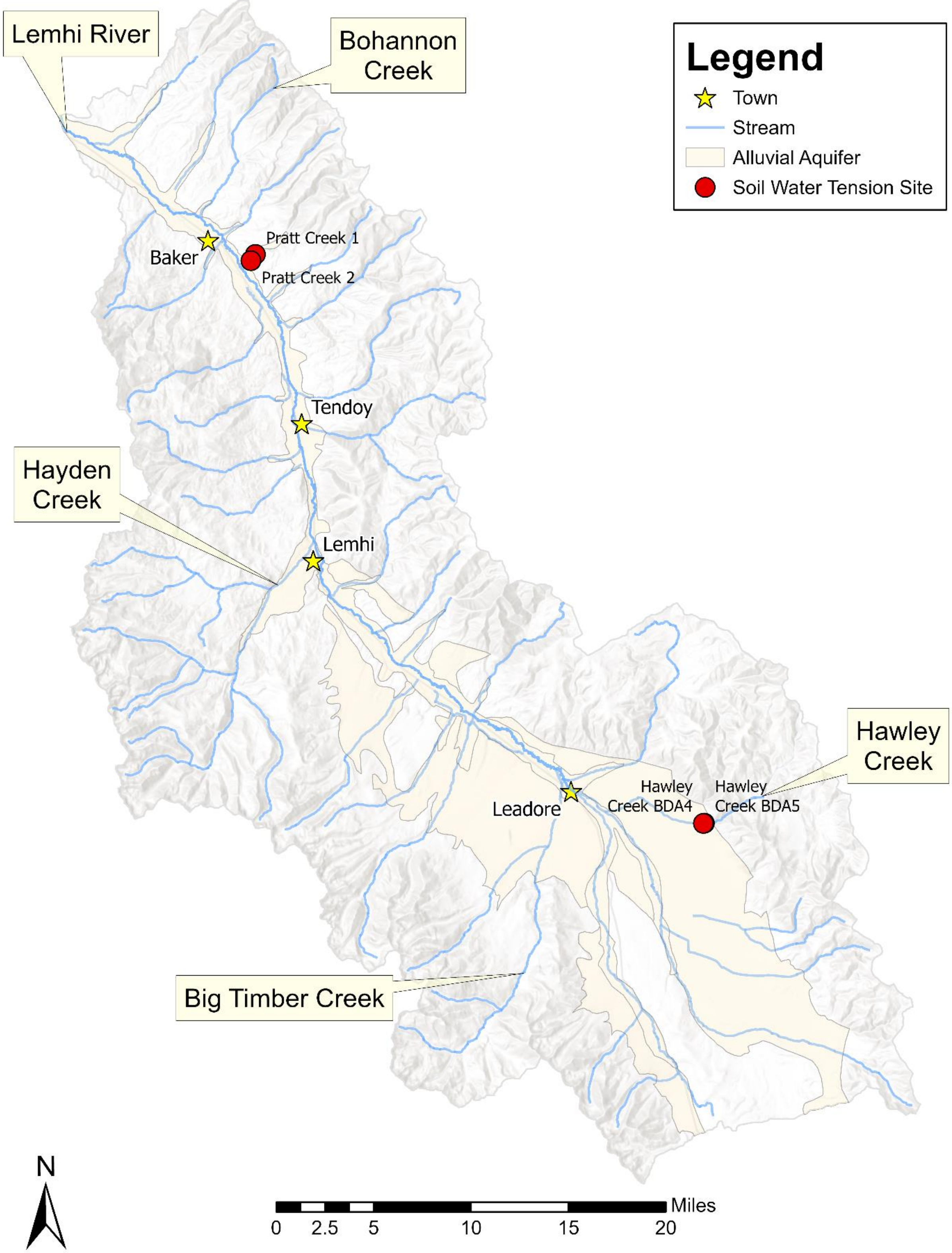


Figure 4. Lemhi Basin soil water tension monitoring network

Task 4 – Surface Water Quality Measurements

IDWR began monitoring surface water quality in the Lemhi Basin in 2020, and data collection is ongoing. This monitoring effort includes periodic measurement of water quality field parameters such as temperature, pH, dissolved oxygen (DO), specific conductivity (SC), and turbidity, as well as collection of grab samples for lab analysis of ammonia as nitrogen (ammonia as N), total nitrogen (TN), total phosphorus (TP), total suspended solids (TSS), total coliform, and *Escherichia coli* (E. coli). In addition, all PCSRF-funded stream gages are equipped to record continuous temperature data. These water quality data are used to identify areas where conditions may adversely affect salmonid habitat, thereby informing the design and evaluation of habitat improvement projects.

IDWR conducted four field campaigns to assess surface water quality during this project, resulting in data collection at 25 sites (Table 4, Figure 5). Grab samples were collected at 12 or more sites in October 2023, May 2024, June 2024, and September 2024. Field parameters were also collected during all sampling events when water quality sondes were operating properly. No field campaigns were conducted in 2025. IDWR plans to resume site visits in spring 2026, with periodic field campaigns continuing through the duration of the Upper Salmon Basin Hydrologic Monitoring and Analyses III project.

All collected water quality data, including lab analyses, field parameter measurements, and continuous water temperature data, will be made available on the IDWR Upper Salmon Basin Hydrologic Project website (https://idwr.idaho.gov/water-data/projects/upper-salmon/references/).

Table 4. IDWR surface water quality measurements in the Lemhi Basin

Surface Water Quality Measurement Site	Latitude	Longitude	Site Visits
Agency Creek at Old Hwy 28	44.959	-113.644	3
Big Eightmile Creek Lower Gage	44.694	-113.482	2
Big Springs Creek Lower Gage	44.728	-113.433	2
Big Timber Creek Lower Gage	44.687	-113.367	2
Bohannon Creek at Lemhi Rd	45.114	-113.744	3
Canyon Creek at Old Hwy 28	44.692	-113.354	2
Eighteenmile Creek at Old Hwy 28	44.683	-113.355	2
Hawley Creek at Hawley Creek Rd	44.658	-113.221	2
Hayden Creek Gage	44.868	-113.628	2
Kenney Creek at Back Rd	45.027	-113.654	3
Lee Creek Gage	44.746	-113.476	2
Lemhi River ab Big Springs Gage	44.729	-113.433	2
Lemhi River ab Hayden Gage	44.868	-113.624	3
Lemhi River ab L-63 Gage	44.682	-113.356	1
Lemhi River at Baker Gage	45.097	-113.721	3
Lemhi River at Cottom Ln Gage	44.749	-113.476	2
Lemhi River at L-1 Gage	45.178	-113.887	3
Lemhi River bl L5 Diversion nr Salmon Gage	45.133	-113.799	2
Lemhi River nr McFarland Gage	44.803	-113.566	2

Surface Water Quality Measurement Site	Latitude	Longitude	Site Visits
Lemhi River nr Lemhi ID Gage	44.94	-113.639	3
Little Sawmill Creek at Hwy 28	44.849	-113.62	2
Little Springs Creek Lower Gage	44.78	-113.544	2
Pratt Creek at Lemhi Rd	45.076	-113.697	3
Texas Creek Gage	44.632	-113.325	1
Wimpey Creek at Old Hwy 28	45.098	-113.72	3

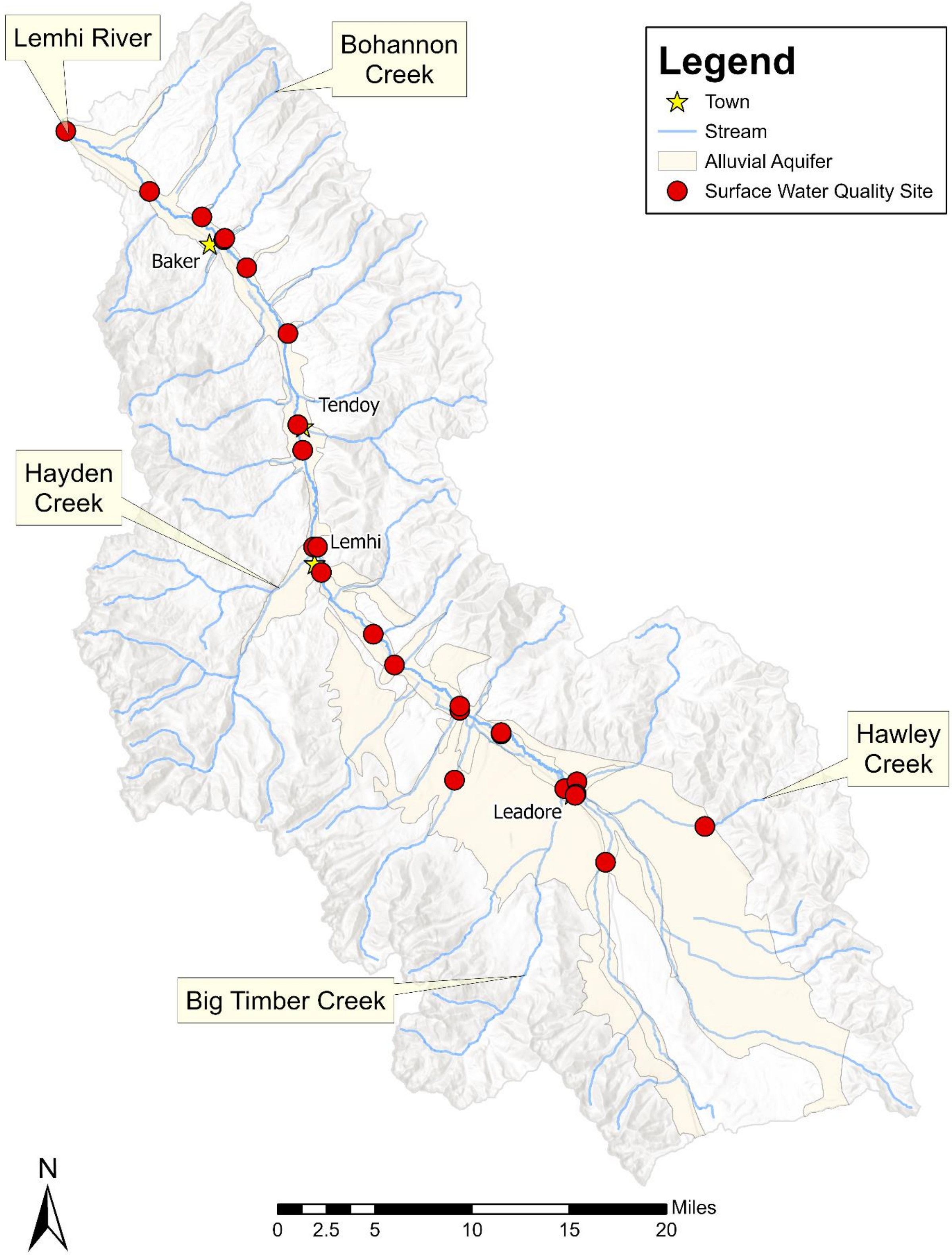


Figure 5. Lemhi Basin surface water quality monitoring sites

Task 5 – LRBM and Associated Tool Updates and Improvements

The project proposal stated that the LRBM Habitat Tool would be updated in two ways:

A) The LRBM Habitat Tool will be updated with recent monitoring data and expanded to include temperature and food supply considerations when evaluating habitat suitability (currently, the tool uses only flow and stage information).
B) The LRBM Habitat Tool will be updated using the hydrologic data from the climate projections that were generated during the 2022 project. The tool can be used to visualize salmonid habitat suitability across multiple potential climate futures.

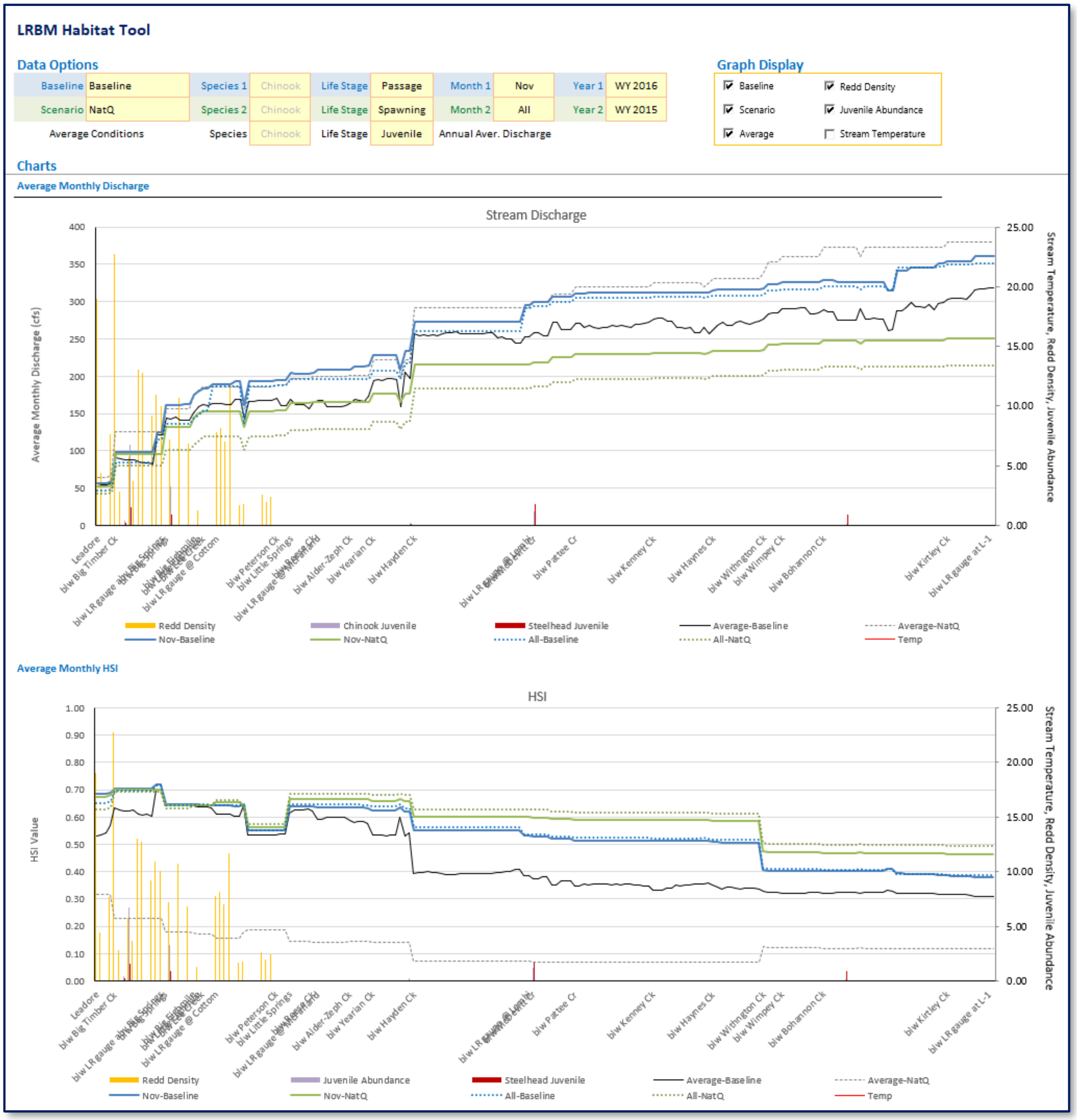
Task 5A. LRBM Habitat Tool update to include temperature and food supply considerations

As described in previous PCSRF progress reports, IDWR was unable to update the LRBM Habitat tool to include temperature and food supply considerations for evaluation of salmonid habitat suitability under varying streamflow scenarios. IDWR was cooperating with the University of Idaho Center for Ecohydraulics (UI-CER) on this tool. UI-CER allowed IDWR to utilize its habitat suitability indexing tool for the Lemhi River Basin in order to develop the LRBM Habitat Tool, which allows for visualization of habitat suitability given a wide variety of streamflow regimes. However, due to competing research interests, the habitat suitability indexing tool was never updated to include temperature and food supply considerations.

Task 5B. LRBM Habitat Tool update to include climate projections

The LRBM-Habitat Tool (LRBM-HT) was developed to assess the impact of catchment runoff and irrigation practices on stream habitat, as they relate to discharge. The LRBM-HT combines the University of Idaho Center for Ecohydraulics (UI-CER) habitat suitability indices (HSI) with juvenile abundance, redd density, and stream temperature data, along with Lemhi River Basin Model (LRBM) discharge output for the Lemhi River. The observed stream temperature data are available within the LRBM-HT for visualization; however, as noted above, temperature is not used as input data in the HSI calculations, which remain based on flow and stage metrics. The LRBM-HT enables evaluation of updated LRBM simulations and associated habitat suitability outcomes. The tool is implemented as an MS Excel workbook (LRBM-HSI.xlsm), which will be made available on the IDWR Upper Salmon Basin Hydrologic Project website (https://idwr.idaho.gov/water-data/projects/upper-salmon/references/).

For the general user, the LRBM-HT only requires interaction with the overview worksheet (LRBM Q-HSI worksheet, Figure 6). This worksheet provides a longitudinal profile of LRBM discharge output and HSI results along the mainstem Lemhi River from Leadore, Idaho, to the confluence with the Salmon River. Additionally, the interface allows users to view historic redd density, juvenile abundance, and stream temperature data for contextual comparison. Users may select among multiple LRBM simulation scenarios and HSI values for multiple Chinook life stages. Results may be displayed by month or water year, including average annual values for water years 2008 through 2023.



LRBM Habitat Tool

Data Options

Baseline	Baseline	Species 1	Chinook	Life Stage	Passage	Month 1	Nov	Year 1	WY 2016
Scenario	NatQ	Species 2	Chinook	Life Stage	Spawning	Month 2	All	Year 2	WY 2015
Average Conditions		Species	Chinook	Life Stage	Juvenile	Annual Aver. Discharge			

Graph Display

☑ Baseline ☑ Redd Density
☑ Scenario ☑ Juvenile Abundance
☑ Average ☐ Stream Temperature

Charts

Average Monthly Discharge

Average Monthly HSI

Figure 6. LRBM HSI sheet in the LRBM-HT

As the original LRBM-HT was developed with MIKE BASIN software (MB), the LRBM-HT workbook was updated to work with the updated LRBM in MIKE HYDRO BASIN (MHB). The updates included:

1) Mapping the HSI river segments to river reaches in the UI-CER HSI analysis. The previous instance had a different set of river nodes.
2) DHI products no longer support VBA coding for loading and writing results from EXCEL to DFS0 files. New methods have been developed to import MHB results and expedite the post-processing analysis (Figure *7*).

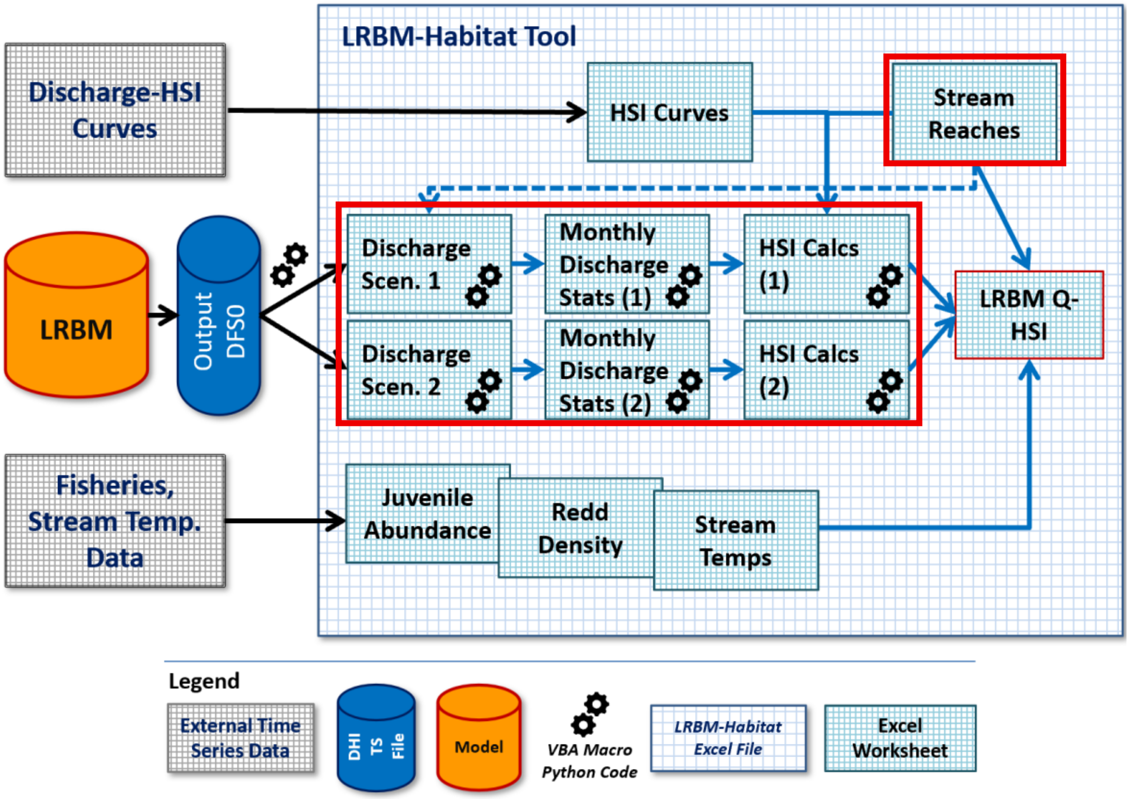


Figure 7. Data flow for the LRBM-HT. For general users, the red outlined worksheet is the primary viewing portal. Red boxes mark the locations where the tool was updated.

Task 6 – Lemhi River Basin Model Scenarios

The LRBM input data, model, and associated tools have been used to support multiple projects that benefit Lemhi Basin salmonid recovery and water management efforts during this project. Progress on modeling products and services that were outlined in the project proposal are detailed below:

A) The LRBM will be used to estimate the impacts of changes to irrigation practices that occurred from 2004 through 2021 using flood and sprinkler irrigation acreage data from the 2022 study.
B) The LRBM will be used to estimate the impacts of potential climate change scenarios on water usage via irrigation water rights.
C) The LRBM will be used to run scenarios submitted by the USBWP Tech Team. The model output data will then be analyzed to evaluate the efficacy of potential future habitat and water transactions projects.

Task 6A. Estimating the streamflow impacts of changes to irrigation

As noted in previous progress reports, uncertainty associated with irrigated acreage estimates and LRBM-modeled streamflow outputs were determined to be too large for this analysis to reliably inform local stakeholders and water managers. However, a preliminary analysis conducted in 2020 evaluated a scenario in which all flood irrigation in the Lemhi Basin was converted to sprinkler irrigation. For this analysis, average monthly discharge was computed at all LRBM nodes along the Lemhi River under both baseline conditions and the full sprinkler conversion scenario. Results were presented to the Tech Team in September 2020. All materials associated with this presentation will be made available upon request.

Task 6B. Analysis of Lemhi Basin streamflow under varying climate projections

Background

Based on CMIP5 and CMIP6 climate models, annual precipitation, daily temperatures, and evapotranspiration are generally projected to increase in Idaho by the year 2100 (Table 5). Data is derived from the USGS National Climate Variability Viewer (Alder and Hostetler, 2013) and the Idaho Climate-Economy Impacts Assessment (Abatzoglou et al., 2021).

Under moderate-emissions scenarios (RCP 4.5, SSP2-4.5), average annual temperatures are projected to rise by 5.5-6.0°F. Under high-emissions scenarios (RCP 8.5, SSP5-8.5), the increase could reach 9.0 to 10.5°F. These changes are expected to be more pronounced during summer months, increasing heat stress and wildfire risk (Alder and Hostetler, 2013). Precipitation patterns are also likely to shift. While annual precipitation may increase slightly (5-10%), the seasonal distribution is projected to change significantly. Winter and spring precipitation may rise by up to 15%, while summer precipitation could decline by 10 to 20%, increasing drought risk (Abatzoglou et al., 2021). Runoff timing is expected to shift earlier by 1 to 2.5 weeks, driven by earlier snowmelt and increased spring precipitation. This shift will reduce streamflow availability during the late summer, impacting water supply for agriculture, ecosystems, and recreation.

Table 5. Projected changes to air temperature and precipitation in Central Idaho by 2100 (Abatzoglou et al., 2021)

Scenario	Climate Model	Projected Emissions	Air Temperature Change [°F]	Air Temperature Change [°C]	Precipitation Change [%]
RCP 4.5	CMIP5	Moderate	+4.5-6.5	+2.5-3.6	+5
RCP 8.5	CMIP5	High	+8.0-11.0	+4.4-6.1	+8
SSP2-4.5	CMIP6	Moderate	+4.5-7.0	+2.5-3.9	+6
SSP5-8.5	CMIP6	High	+9.0-12.0	+5.0-6.7	+10

The Decision Scaling Method (DSM) was used to evaluate the impacts of potential climate change in the Lemhi Basin. The DSM is a robust, bottom-up approach to water resources management under climate uncertainty. It helps planners and engineers design systems that are resilient to a wide range of possible future climate conditions, rather than relying solely on specific climate model projections (Ray and Brown, 2016). The method involves determining flow evaluation metrics, running analytical models to assess the impacts of climate variability on water resources systems, and mapping climate projections to assess the climate risk to those systems under a range of projections. The benefits of this method include a focus on system resilience and adaptive capacity, as well as its applicability to a wide range of water management infrastructure and policies.

Methods

To assess the potential impacts of climate change on water availability for irrigation and ecosystems, the DSM has been applied to the Lemhi Basin. The LRBM rainfall-runoff model (NAM) was used to predict how catchment runoff would respond to varying temperature and precipitation conditions. The LRBM simulated varying runoff conditions to determine the sensitivity of irrigation (irrigation elasticity) to changes in water supply, and the predicted conditions from climate models were mapped to provide a spectrum of potential water resource futures under climate uncertainty. More specifically, the analysis followed the steps outlined below:

1) **Climate Scenarios**: By varying the historic temperature input timeseries by 5°C (9°F) increments from -10°C to +10°C and the historic precipitation input timeseries by 10% increments from -20% to +20%, 25 climate scenarios were generated using the LRBM NAM model. The LRBM NAM model simulated daily timesteps from October 1, 1991, to October 1, 2024, thereby capturing periods of drought and abundance. The LRBM NAM catchment runoff output was summarized to estimate climate impacts on annual runoff volume (water availability), peak discharge magnitude, and peak runoff timing.
2) **Demand Sensitivity**: The Baseline Scenario (1991 to 2024 average) catchment runoff timeseries were varied by 10% intervals, from -20% to +20%, and the LRBM simulated water supply and deficit of water users. For each water user node, the average delivery rate, average relative deficit, and violations were computed, and these were combined to determine basin performance. Violations were defined as two or more water users receiving less than 85% of the demand on the same day. This sensitivity analysis illustrates the rate at which water delivery changes given a unit change in water supply. This is otherwise known as “water user demand elasticity”.
3) **Resource Management Evaluation**: By combining projected changes in catchment runoff from climate scenarios with demand elasticity, this analysis evaluated the susceptibility of water users to climate-driven variability in the Lemhi Basin. In addition, mapped climate model projections for both moderate-emissions scenarios (RCP4.5, SSP2-4.5) and high-emissions scenarios (RCP8.5, SSP5-8.5) were used to identify and prioritize issues requiring consideration in future water resource planning and management decisions.

To assess the impact of climate on water availability for irrigation and ecosystems, the Decision Scaling Method has been applied to the Lemhi Basin (Figure 8). Using the LRBM and scaled climate projections as the basis for analysis, eight climate scenarios representing a range of precipitation and temperatures were evaluated. Preliminary results indicate that, within the model framework, the irrigation water delivery is less susceptible to changes in temperature and precipitation than maintaining ecosystem flows. Results should be interpreted within the context of the assumptions and limitations described at the end of this analysis.

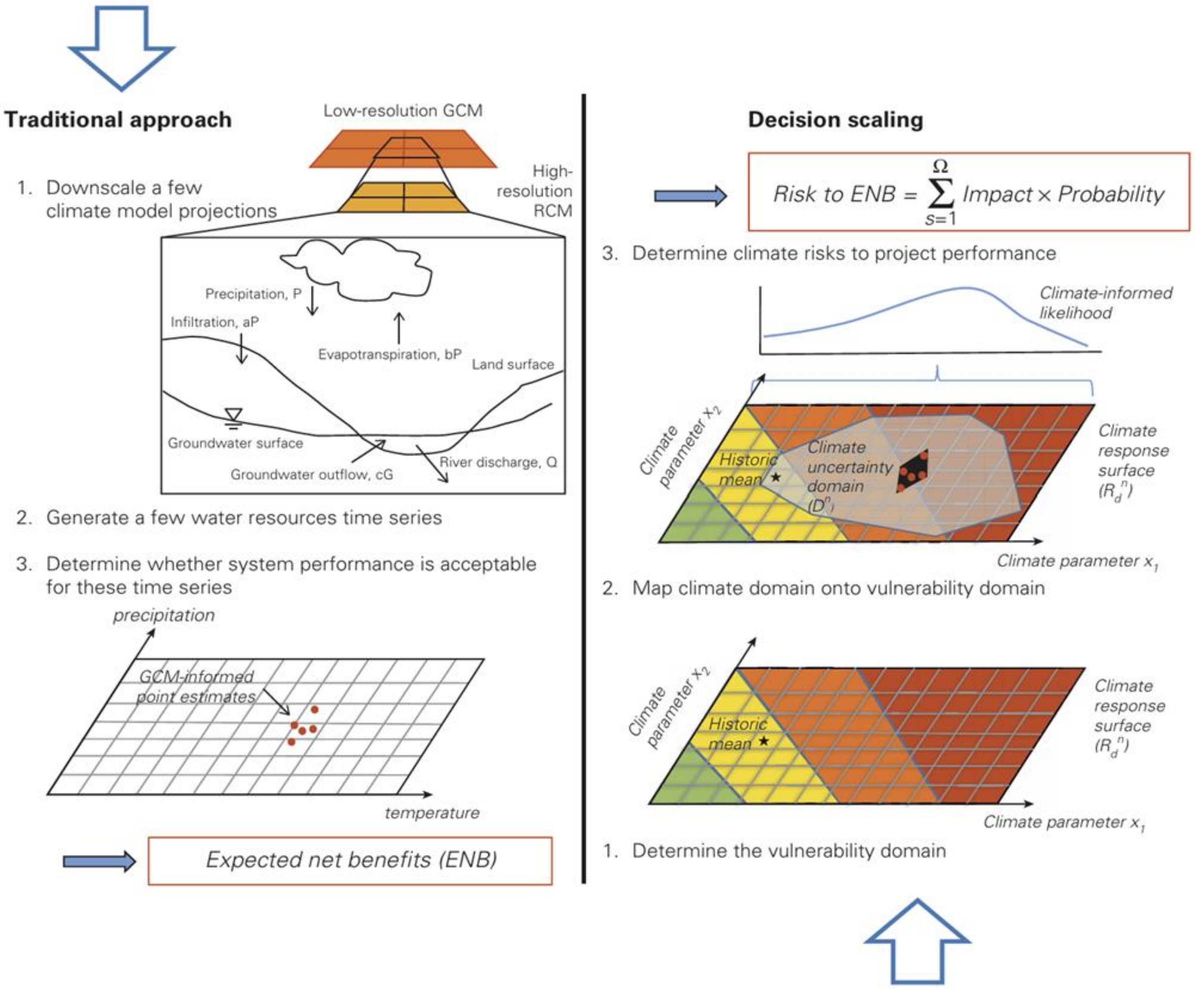
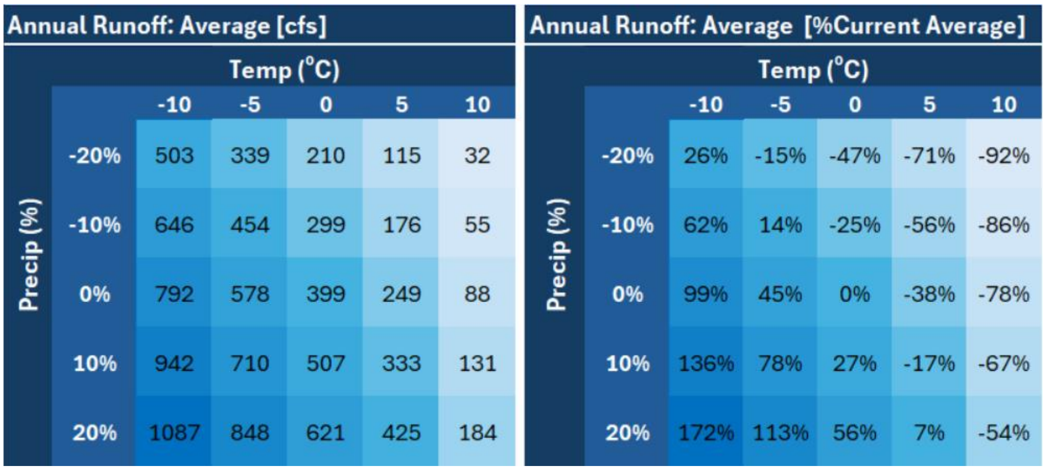


Figure 8. Method of assessing the impacts of climate variability on water resources (Ray and Brown, 2016)

Runoff Quantity Trends

Annual runoff: Annual runoff increased with higher precipitation but was strongly moderated by temperature (Figure 9). Holding precipitation at the current level, annual runoff ranges from 792 cfs to 88 cfs with a -10 °C and +10 °C change from the baseline temperature (1991 to 2024 average). This results in a 99% increase and a 78% decrease in annual runoff, respectively, yielding a -8.5% annual runoff per +1^{o}C temperature change. The annual runoff results also show dependence on precipitation magnitude. Holding temperature constant, precipitation shifts from −10% to +10% across all temperature conditions. Under baseline temperature conditions (0 °C change), average annual runoff increases from about 210 cfs to 621 cfs at -20% and +20% precipitation, representing -47% and +56 % changes in runoff, respectively. Thus, for every +5% increase in precipitation, runoff increases by +2.6%. The extremes range from 32 cfs (warm-dry (+10^{o}C, -20% precipitation)) to 1087 cfs (cold-wet (-10^{o}C, +20% precipitation)), a -92% and +172% change, respectively. While the climate models suggest that these climate extremes are unlikely to occur by the year 2100 (Table 5), the runoff projections still provide additional information on catchment sensitivity to climate change.



Annual Runoff: Average [cfs]

Precip (%)	Temp (°C) -10	-5	0	5	10
-20%	503	339	210	115	32
-10%	646	454	299	176	55
0%	792	578	399	249	88
10%	942	710	507	333	131
20%	1087	848	621	425	184

Annual Runoff: Average [%Current Average]

Precip (%)	Temp (°C) -10	-5	0	5	10
-20%	26%	-15%	-47%	-71%	-92%
-10%	62%	14%	-25%	-56%	-86%
0%	99%	45%	0%	-38%	-78%
10%	136%	78%	27%	-17%	-67%
20%	172%	113%	56%	7%	-54%

Figure 9. Mean annual runoff and percentage change for the 25 scenarios, with varying temperature and precipitation

Scenarios representing the extremes of wet-dry and cold-warm conditions provide boundaries for the most intense effects on catchment runoff (Figure 9, Figure 10). The extremes range from warm-dry conditions averaging 32 cfs (+10°C, -20% precipitation) to cold-wet conditions averaging 1087 cfs (+10°C, +20% precipitation), a -92% and +172% change from the current state, respectively. Cold-dry conditions (-10 °C, -20% precipitation) only increased catchment runoff by 26%, while warm-wet conditions (+10 °C, +20% precipitation) decreased catchment runoff by -54%. With respect to catchment runoff, warming temperatures have a greater impact, largely due to impacts to the snowpack.

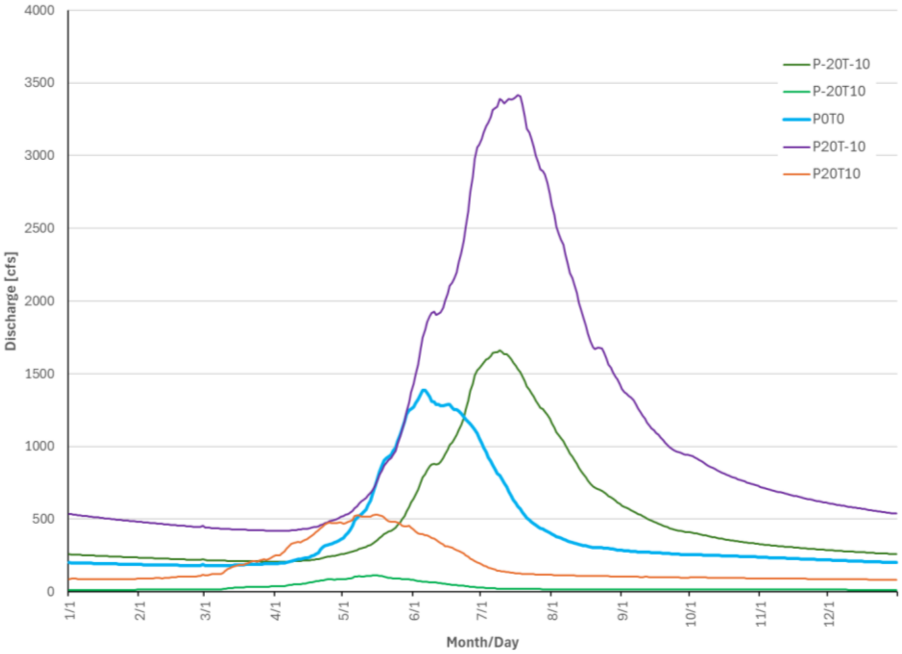
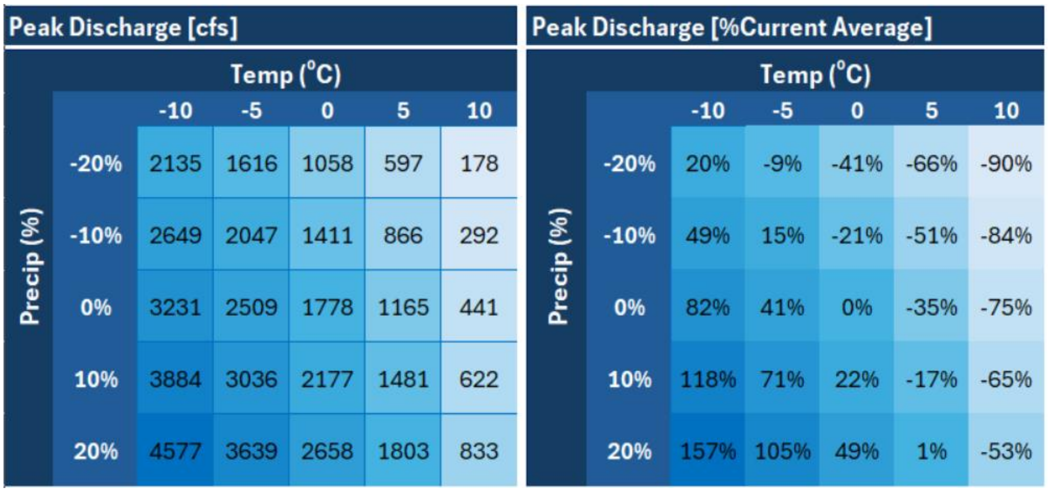


Figure 10. Average annual catchment runoff for the extreme wet-dry and cold-warm conditions. In the legend labels, P# represents percent change in precipitation and T# represents the shift in temperature.

Peak discharge pattern: Peak discharge exhibits the same trend as annual runoff, with temperature more strongly moderating peak discharges (Figure 11). Holding precipitation at the current level (0% change), peak discharges range from 3231 cfs to 441 cfs with a -10 °C and +10 °C change. This results in 82% and -75% increases in annual runoff, respectively. The rate of change below 0°C is -145 cfs/+ 1°C compared to -134 cfs/+1 °C above 0°C. The rates of change decrease with decreasing precipitation in the basin, but remain negative, with lower rates of change in scenarios with temperature increases above 0°C. The difference in rate is largely due to change in the snow component. When expressed as a percentage of the current average, these values transition from well above 100% under cool, wet conditions to near or below average under warmer conditions. This pattern indicates that warming moderates flood peaks by reducing snowmelt intensity and spreading runoff over time, even when total precipitation increases (Figure 12).



Peak Discharge [cfs]

Precip (%)	Temp (°C) -10	-5	0	5	10
-20%	2135	1616	1058	597	178
-10%	2649	2047	1411	866	292
0%	3231	2509	1778	1165	441
10%	3884	3036	2177	1481	622
20%	4577	3639	2658	1803	833

Peak Discharge [%Current Average]

Precip (%)	Temp (°C) -10	-5	0	5	10
-20%	20%	-9%	-41%	-66%	-90%
-10%	49%	15%	-21%	-51%	-84%
0%	82%	41%	0%	-35%	-75%
10%	118%	71%	22%	-17%	-65%
20%	157%	105%	49%	1%	-53%

Figure 11. Peak annual runoff and percentage change for the 25 scenarios, with varying temperature and precipitation

The peak runoff results show a strong dependence on precipitation magnitude, which increases as precipitation shifts from -10% to +10% across all temperature conditions (Figure 11). Under baseline temperature conditions (0 °C change), average annual runoff increases from about 1058 cfs to 2658 cfs at -20% and +20% precipitation, representing -47% and +56 % changes in runoff, respectively. Thus, for every +5% increase in precipitation, peak runoff increases by +2.6%. Unlike changes in temperature which alter the hydrograph timing, changes in precipitation maintain the hydrograph shape, and only alter the magnitude of discharge. Thus, the LRBM NAM rainfall-runoff model indicates that precipitation controls the overall water available for catchment runoff, with a relatively minor influence on timing compared to temperature.

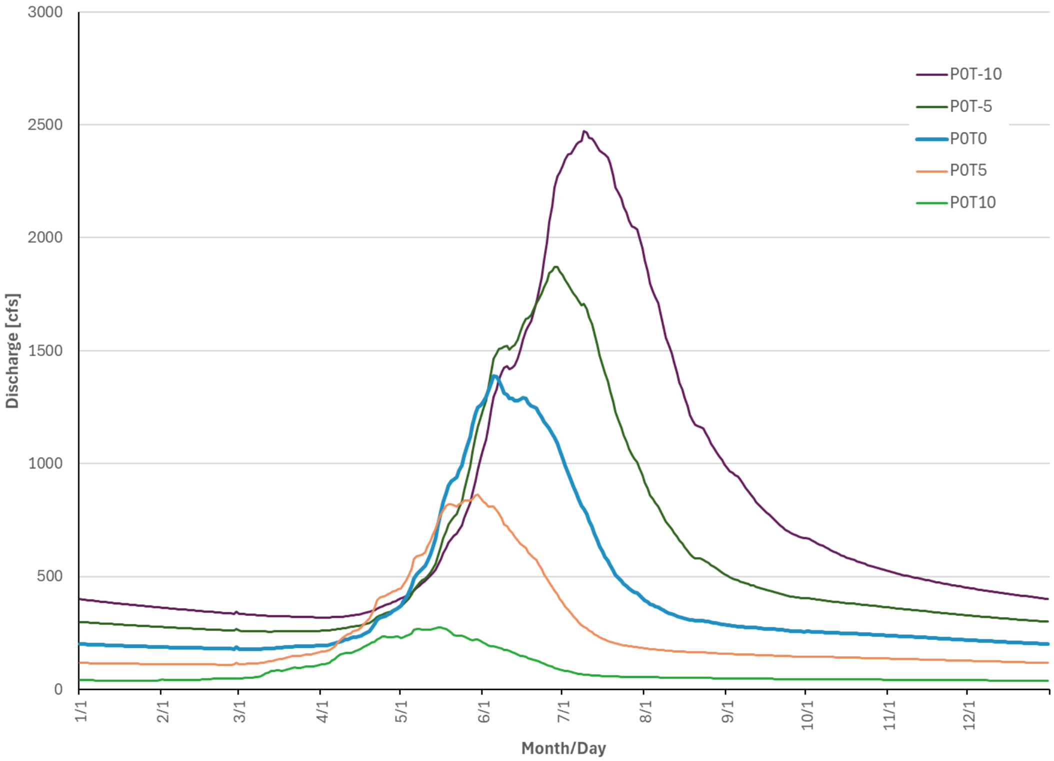
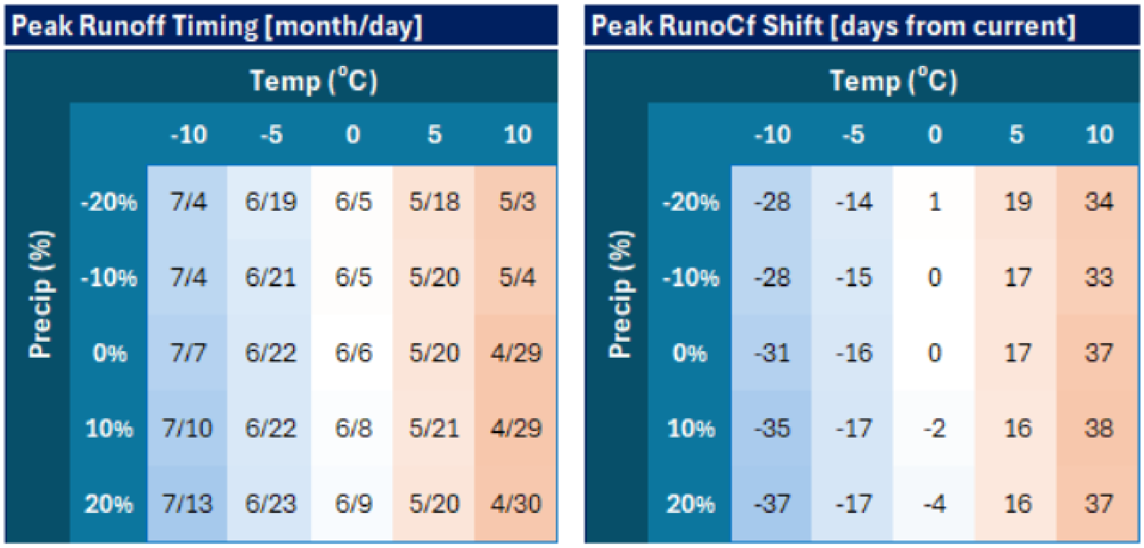


Figure 12. Average annual catchment runoff for changing temperatures while holding precipitation at current rates. In the legend labels, P# represents percent change in precipitation and T# represents the shift in temperature.

Timing of Peak Runoff: Temperature and precipitation also shift the timing of peak runoff (Figure 13). At colder temperatures (-10°F), peak runoff occurs in early to mid-July, while at warmer temperatures (+10°F), it shifts to late April or early May. For instance, at 0% precipitation change, peak runoff moves later 31 days at -10°F and moves earlier 37 days at +10°F. Reduced snowpack and earlier melt drive this shift, compressing the runoff season and altering the timing of water availability. Increased precipitation slightly delays peak runoff under colder conditions, likely because a deeper snowpack takes longer to melt.



Peak Runoff Timing [month/day]

Precip (%)	Temp (°C) -10	-5	0	5	10
-20%	7/4	6/19	6/5	5/18	5/3
-10%	7/4	6/21	6/5	5/20	5/4
0%	7/7	6/22	6/6	5/20	4/29
10%	7/10	6/22	6/8	5/21	4/29
20%	7/13	6/23	6/9	5/20	4/30

Peak RunoCf Shift [days from current]

Precip (%)	Temp (°C) -10	-5	0	5	10
-20%	-28	-14	1	19	34
-10%	-28	-15	0	17	33
0%	-31	-16	0	17	37
10%	-35	-17	-2	16	38
20%	-37	-17	-4	16	37

Figure 13. Shift in peak runoff across the 25 scenarios, with varying temperature and precipitation.

Underlying Causes (Snowpack and Evapotranspiration): The primary driver of these changes is the snowpack, which acts as a seasonal reservoir. In colder climates, snow accumulates and melts in spring, producing concentrated runoff. Warmer temperatures reduce snow accumulation and cause earlier melt, leading to earlier runoff, and, in many cases, reduced peak discharge. Additionally, evapotranspiration increases with temperature, pulling more water from the soil and vegetation, further reducing runoff and peak flows.

Sector Sensitivity

To test the impacts of potential climate change on irrigation reliability (IRR) and aquatic habitat flows (ENV), the LRBM simulated impacts to irrigation and streamflow with catchment runoff reductions of -20%, -10%, Baseline, +10%, and +20% (Figure 14). To evaluate irrigation reliability in response to changing catchment runoff, the water delivery deficit was computed for each of the 322 water user nodes in the LRBM. Days were flagged when the relative deficit exceeded 15% (deficit/demand). The number of water user nodes with flagged days during a year was summed to derive the irrigation performance. The reported irrigation performance index is the percentage change in the number of water users with flagged days in each climate change scenario when compared to the baseline simulation (average conditions from 1991 to 2024).

Aquatic habitat conditions (ENV) were evaluated using the LRBM-Habitat Tool (LRBM-HT), a post-processor developed to assess the impact of catchment runoff and irrigation practices on stream habitat in relation to discharge (see Task 5 for details). For each of the 196 river segments defining the Lemhi River in the LRBM, one of eight habitat suitability indices (HSI) developed by UI-CER is applied to the modeled discharge to derive an HSI score for the daily time step. For this evaluation, the average discharge for each river segment was calculated in August across the simulation period, and the appropriate HSI curve was then applied. Note that August was selected because it represents a critical low-flow period for juvenile Chinook and Steelhead rearing. Once the HSI was calculated for each segment, the results were averaged across simulation runs to derive an average HSI score for the Lemhi River. The reported aquatic habitat performance index is the percentage change from the baseline simulation (Figure 14).

Results from the sensitivity analysis of irrigation reliability and aquatic habitat flows indicate that, for catchment runoff conditions below baseline, both were negatively impacted (Figure 14). At a -20% catchment inflow, both sectors experienced a performance decrease of around -14%. At a -10% catchment inflow, the IRR performance was roughly -8%, while the ENV was roughly -2%. Thus, IRR performance improves approximately linearly (over the evaluated range) with increased catchment runoff, whereas ENV performance increases quickly until -10% runoff, then improves linearly.

Increased catchment runoff produced different responses across sectors. In the IRR sector, reliability gains plateaued, rising only 2% even with a 20% increase in catchment inflow. In contrast, the ENV sector showed a stronger response to increased runoff, with reliability increasing by 16% and 22% under +10% and +20% catchment inflow scenarios, respectively. These gains reflect higher August streamflow, which improves rearing habitat conditions for juvenile Chinook and Steelhead.

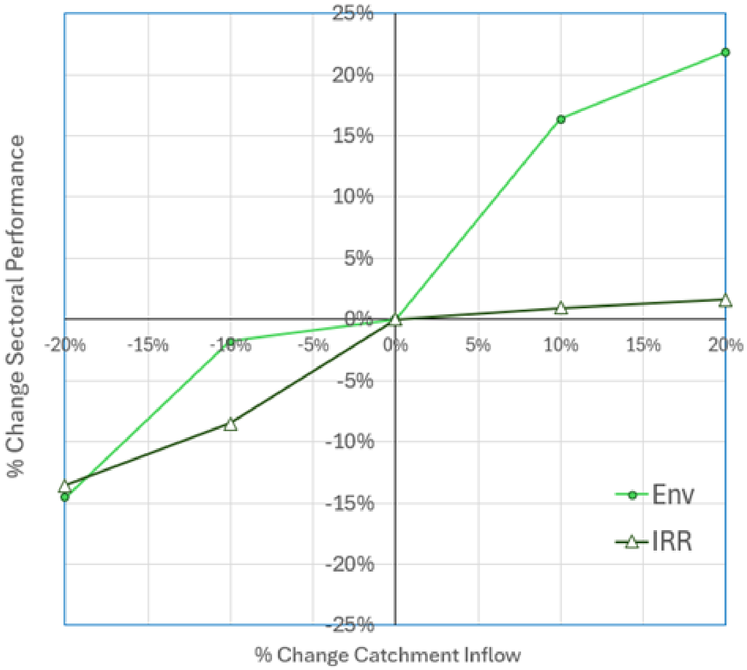
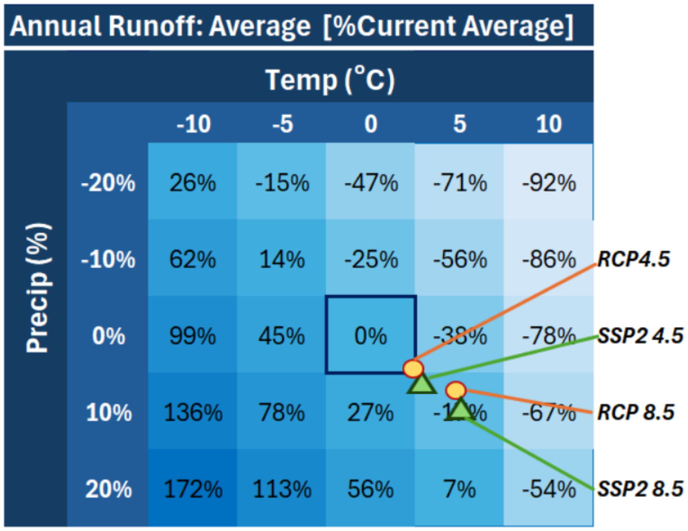


Figure 14. Performance analysis of irrigation reliability and aquatic habitat flows under changing catchment inflow

Predicted Climate Variability Impacts: As stated, under moderate-emissions scenarios (RCP 4.5, SSP2-4.5), average annual temperatures are projected to rise by 2.5-3.9 °C (4.5-7.0 °F) by 2100 (Table 5). Under high-emissions scenarios (RCP 8.5, SSP5-8.5), the increase could reach 6.1-6.7ºC (11.0-12.0 °F). Precipitation is projected to increase from 5-10%. With the computed average annual catchment runoff for each scenario, the average catchment runoff is predicted to decrease by 12-13% for the moderate-emissions scenarios and 23-24% for the high-emissions scenarios (Table 6). Decreases in catchment runoff are primarily driven by higher temperatures. Though the basin is expected to experience increased precipitation, this increase does not offset the negative impacts of rising temperatures on catchment runoff.

Table 6. Predicted change in catchment runoff under the climate scenarios

Climate Scenario	Temp Δ [°C]	Precip Δ [%]	Average Runoff [cfs]	Runoff Δ [%]
RCP 4.5	3.05	5%	373	-13%
RCP 8.5	5.25	8%	327	-24%
SSP2 4.5	3.20	6%	378	-12%
SSP2 8.5	5.75	10%	330	-23%
Current	0.00	0%	429	0%


Annual Runoff: Average [%Current Average]

Precip (%)	Temp (°C) -10	-5	0	5	10
-20%	26%	-15%	-47%	-71%	-92%
-10%	62%	14%	-25%	-56%	-86%
0%	99%	45%	0%	-38%	-78%
10%	136%	78%	27%	-1[illegible]%	-67%
20%	172%	113%	56%	7%	-54%

Figure 15. Lemhi Basin runoff projections under variable RCP and SPP climate projections for central Idaho

In addition to a decrease in catchment runoff, peak runoff will occur earlier in the season, followed by extended periods of low flow. Currently, the average peak runoff occurs on June 6. Based on a linear regression of the temperature and precipitation changes with the average date of peak runoff for each scenario, under moderate-emission scenarios, the peak will occur 11 days earlier, averaging around May 26 (Table 7). Using the upper and lower temperature range for the moderate-emissions, the shift could span between 9 and 13 days. Under high-emissions scenarios, peak runoff shifts nearly 3 weeks, occurring on average around May 18. Given the reported temperature range, this shift is predicted to be 15 to 23 days earlier.

Table 7. Predicted shift in peak runoff under the climate scenarios. Note, positive shift adjusts the peak runoff date earlier in the year

Climate Scenario	Temp Δ [°C]	Precip Δ [%]	Days Shift	Peak Date
RCP 4.5	3.05	5%	11	5/26
RCP 8.5	5.25	8%	18	5/19
SSP2 4.5	3.20	6%	11	5/25
SSP2 8.5	5.75	10%	19	5/17
Current	0.00	0%	0	6/6

Based on catchment runoff, both the IRR and ENV sectors will be negatively affected. In moderate-emission scenarios, irrigators are likely to observe reduced delivery of -12% to -5%. Under these reduced catchment runoff conditions, ENV flows are slightly more buffered against decreases in sectoral performance and are predicted to be around -3 % when catchment inflow is reduced by 12%. In the high-emission scenarios, both IRR and ENV performance are likely to drop to around -14%. Coupling the decreased runoff with earlier freshet timing, irrigators and fisheries will need to adapt to earlier irrigation onset and longer-duration low-flow periods throughout the summer, with less water available.

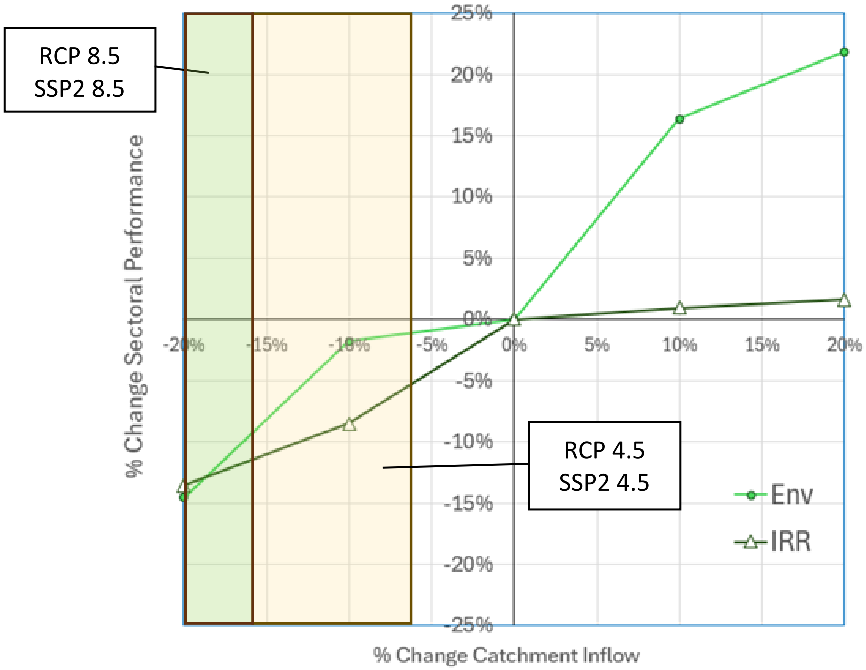


Figure 16. Changes to Lemhi Basin irrigation and aquatic habitat flow reliability under variable RCP and SPP climate projections

Management Implications: These projected hydrologic shifts pose challenges for irrigation and fisheries. Earlier runoff may not coincide with peak irrigation demand in summer, necessitating adjustments to irrigation strategies to prepare for the summer irrigation season when water supply decreases due to reduced streamflow. Reduced peak flows can impact fish spawning, especially for species that rely on high spring flows to access upstream habitats. To maintain a reliable water supply for salmonid habitat and agriculture under variable climate futures, water managers and stakeholders will likely need to leverage water resource forecasting tools, monitor ecosystem health, and implement adaptive farming and irrigation practices.

Limitations and Assumptions

The climate impact assessment includes the same limitations as those described in the modeling development and rainfall-runoff modeling documentation (IDWR, 2019), but includes a few additional caveats regarding scaling input data, PET, and irrigation demand sensitivity. These assumptions simplify the analysis and isolate the effects of temperature and precipitation on runoff but may not fully capture the Lemhi Basin’s vulnerability to climate change. Water managers should be aware that actual reductions in runoff may exceed those predicted by the model, especially in scenarios with substantial warming.

Scaling Temperature and Precipitation: The 25 climate scenarios assume the Scaling Temperature is adjusted globally in increments of 5 °C and precipitation is adjusted by multiples of 10%. These intervals do not account for shifts in seasonal weather patterns, the increasing magnitude of precipitation events, nor the duration of drought. Adjusting seasonal temperature and precipitation magnitude and timing to the global climate models' output involves downscaling the results to the Lemhi Basin, which was beyond the scope of this study.

Potential Evapotranspiration (PET): While the LRBM NAM model provides a practical framework for scenario analysis, its lumped conceptual structure and the assumption of unchanged PET introduce limitations. The model's simplifications may lead to underestimation of spatial and process variability, and the fixed PET assumption likely results in optimistic runoff predictions under warming scenarios. PET is highly sensitive to temperature, solar radiation, humidity, and wind speed. As temperature increases, PET typically rises, leading to greater water loss from soil and vegetation. By keeping PET fixed, the scenarios may underestimate the reduction in runoff that would occur under warmer conditions, since actual evapotranspiration would likely increase.

Water Demand Sensitivity: In assessing demand sensitivity to changing water supply, scaling the basin runoff from the baseline scenario only shifts the magnitude of runoff and does not change the timing of the spring freshet or overall shape of the hydrograph. From the 25 climate scenarios simulated using the NAM model, increasing the temperature, and to a lesser degree precipitation, changes the timing of the peak runoff. Further investigation is required to determine the metric's sensitivity to temporal shifts in the hydrographs.

Task 6C.1. Bar 20 Flood to Sprinkler Conversion

The Tech Team was evaluating a potential conversion from flood irrigation to sprinkler irrigation along Hayden Creek (Figure 17). Historically, the HC-7 diversion supplied up to 6.36 cfs from Hayden Creek to service 10 base water rights. Under the proposed conversion, modeled delivery to 36 acres associated with water rights 74-1781 and 74-16025 would be reduced from approximately 1.15 cfs to 0.4 cfs.

In the LRBM, the irrigation demand associated with HC-7 was reduced by 0.75 cfs, and the model was used to evaluate delivery reliability and downstream effects. The results showed a general decrease in diverted discharge to HC-7 (Figure 18). Because the LRBM applies to historic hydrologic conditions, reduced demand at HC-7 results in a corresponding reduction in simulated diversion during periods when historic flows were insufficient to meet full demand. During periods of low flow, the reduced diversion at HC-7 increased the volume of water remaining in Hayden Creek, which was subsequently available to downstream diversions such as HC-5 (Figure 19). As the primary purpose of the conversion was to augment downstream flow in Hayden Creek, the Tech Team considered these results when evaluating the proposed irrigation conversion project.

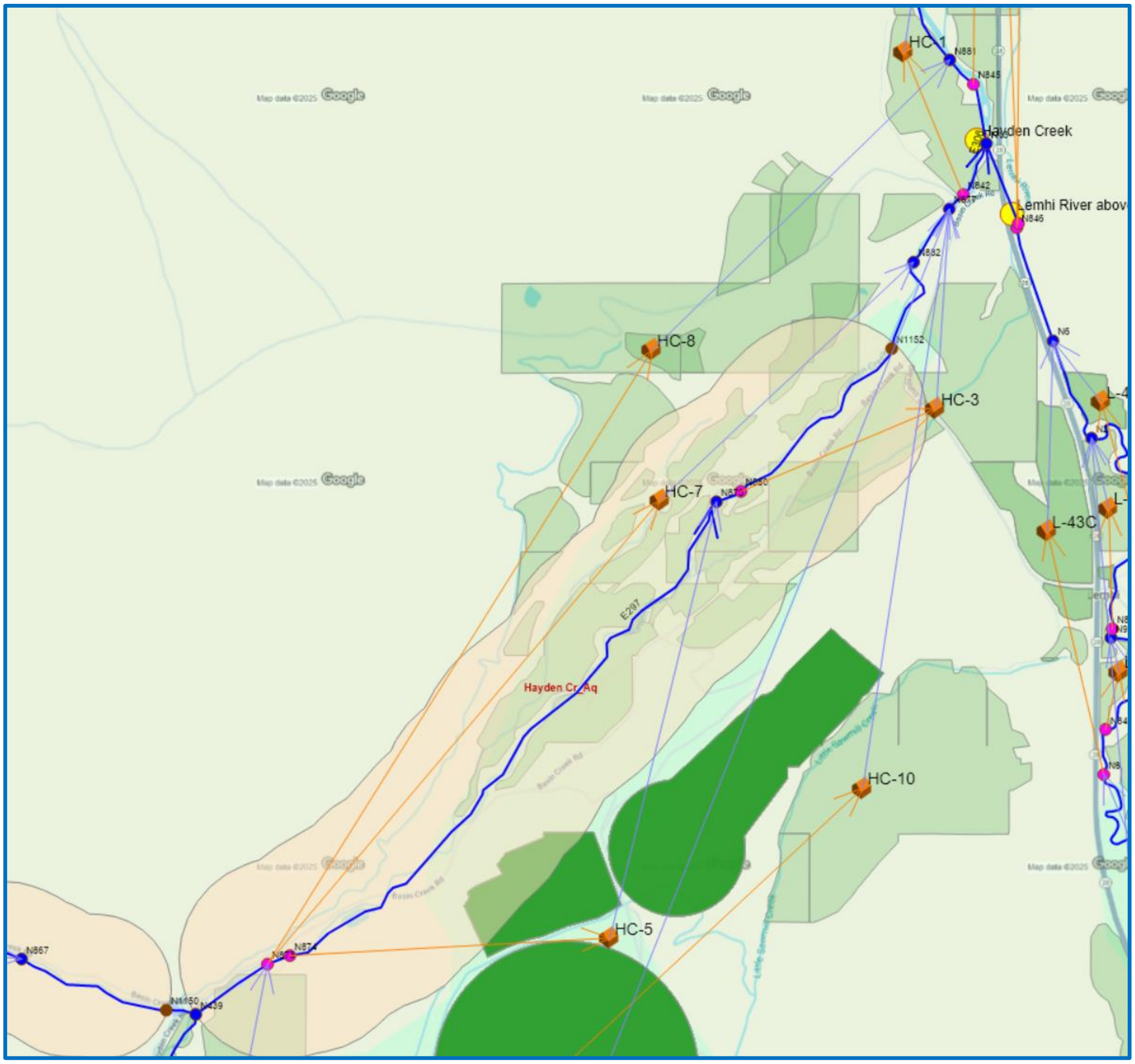


Figure 17. Proposed conversion from flood to sprinkler irrigation from Hayden Creek. Arrows mark the POD and return flow locations.

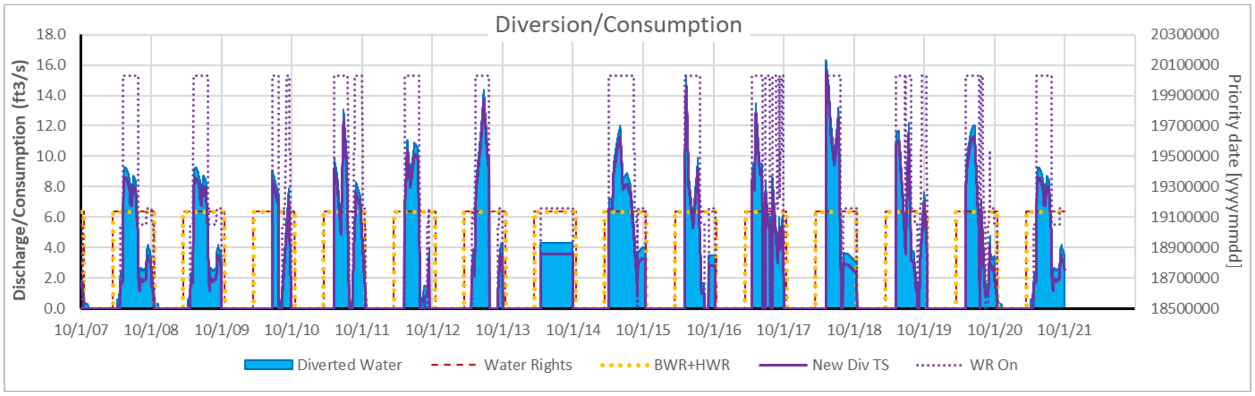


Figure 18. Diversion from the HC-7 POD/POU with and without the irrigation conversion. Note, *BWR* is base water rights, *HWR* are high water rights, *newDiv TS* is the new demand given the irrigation conversion, and *WR* on denotes the periods when the POD water right is active.

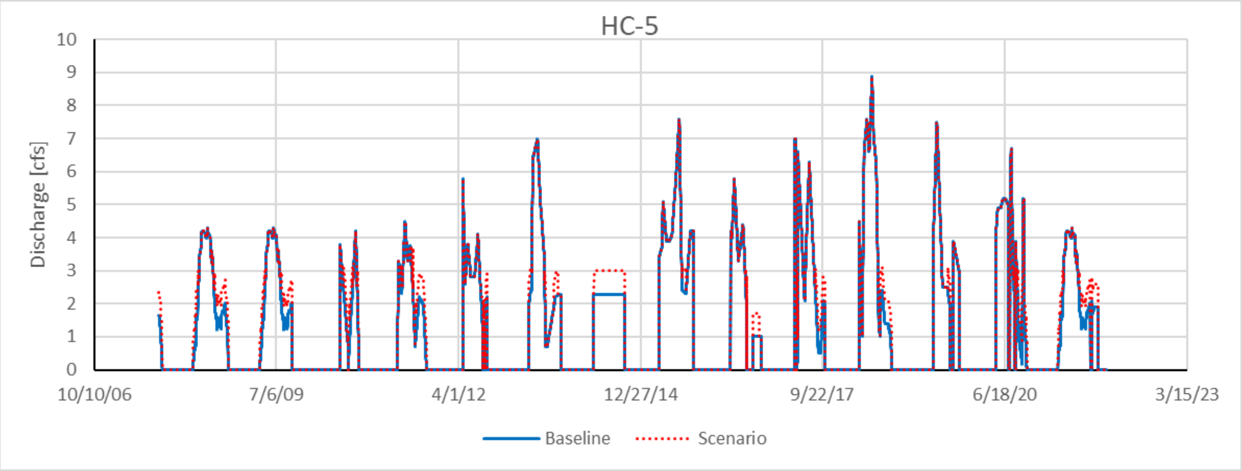


Figure 19. Diversion from the HC-5 POD/POU under Baseline and with the irrigation conversion (Scenario).

Task 6C.2. Support Lemhi Settlement Steering Committee

IDWR continued to support enactment of the Lemhi River nr McFarland Gage minimum streamflow requirement, a term in the Lemhi Settlement Agreement, by refining flushing-flow analyses and monitoring-reach methodology as well as participating in Lemhi Settlement Steering Committee meetings. The LRBM Pulse Calculator tool, which was developed in 2021 (IDWR 2022), was integral to supporting these efforts.

Task 6C.3. Development of Streamflow Projections at the Lemhi River at L-6

In the Lemhi Basin, the IWRB's Water Transactions Program (IWTP) rents water from irrigators to supplement flows at the L-6 minimum streamflow (MSF) to comply with the minimum streamflow appropriation (Idaho Code 42-1506). The amount of water to be rented depends on the hydrologic conditions and irrigation practices. Improved insight into water availability and the required transactions would enhance IWTP's ability to manage rental agreements. Based on the information gathered and the LRBM's predictive power, the model could serve as a basis for developing rental guidelines for IWRB staff to use when contracting leases.

To support this effort, a conceptual document was written to outline the methodology, data sources, required outputs, and project plan for developing the L-6 Subordination Probability Model (L-6 Model). The L-6 Model is scheduled to be completed during the Upper Salmon Basin Hydrologic Monitoring and Analyses III project. The primary findings of the conceptual document are as follows:

Concept: L-6 MSF subordination contracts are a maximum of 100 days/yr. The Water District 74 irrigation season is 241 days. In low-water years, such as 2021 and 2022, the subordination demand to maintain the MSF exceeds the maximum subordination contract timeline (100 days). Ideally, IWTP could predict early-season irrigation demand and late-season dryness, as both factors affect the subordination demand at L-6. For example, if irrigators turn on early, the IWTP can use up 30+ days of contract water before peak streamflow occurs. Then, if weather conditions are hot and dry in the fall, subordination demand can last longer than the historical average. Knowing the magnitude and duration of baseflow conditions as early as possible (Jan-Feb and Jun-July, respectively) would allow the IWTP more time to secure drought emergency contracts (30-50 additional subordination days) with water users. Knowing future flow is one thing; knowing where to best spend time and effort securing subordination contracts is another.

L-6 Model Requirements:

- *Discharge Assessment*: A tool that can predict the probability of flows <35 cfs from March 15 - Jun 30 (Spring), and <25 cfs Jul 1 - Nov 15 (Summer) at the Lemhi River bl L-5 gage.
    - Assessing the need for IWTP rentals requires understanding basin runoff and irrigation demand during the spring and late summer periods. Both periods will require characterization of streamflow timing and quantity, as well as irrigation practices. Spring will require further characterization of when irrigation is initiated and how that timing changes under varying climatic conditions.
- *Diversion Guidance*: Under low-flow conditions, a tool that can predict the "effectiveness" or "cost-benefit" of a specific subordination contract at a specific diversion. For example, if 5 cfs with an 1878 priority date spilled past L-14, what portion is predicted to be instream at L-6 after accounting for evaporation and seepage? Anecdotally, the WD74 watermaster currently curtails as much as 40 cfs from the reaches above L-9 (the most upstream diversion with an L-6 MSF subordination contract) to make 25 cfs at L-6 on any given 90 – 100°F Day in August or September. Would subordination contracts L-10 to L-17 have any appreciable effect on maintaining the L-6 MSF?
- *Analysis Required*: Using the LRBM and supporting tools, determine the available water rights/diversion rates that could be rented to supplement discharge at the Lemhi River bl L-5 gage. Characterize typical diversion rates along the mainstem Lemhi River and determine if intervening diversions between the rental diversion and Lemhi River bl L-5 gage would take the excess discharge. Updating the reach gains would be important for assessing losses to ET and seepage gains within this reach.
- *Output*: An Excel workbook that, based on an entered priority date and current/projected discharges, displays the diversion rates for each diversion as well as the likelihood that the discharge would make it to the L-5 gage. Additionally, costs and durations for specific water years can be added. The results could also be displayed on a map for IWRB to understand conditions spatially and discuss with stakeholders.

Task 7 – Pahsimeroi River Basin Model

Under this task, the Pahsimeroi River Basin Model (PRBM) was migrated from MB to MHB. MHB and MB are not compatible, so the PRBM needed to be restructured. The 2008 MB model was a skeleton model, meaning it included the stream and irrigation network system, but not catchment inflows, irrigation diversions, or gaged information required to run model scenarios. MHB construction involved migrating the branch and water user node MB files into MHB, constructing the catchments, connecting the water user nodes, and reassigning the timeseries files to the appropriate model elements. This provides a new skeleton model from which to develop a fully parameterized and calibrated PRBM capable of running a wide range of streamflow scenarios, like the LRBM. The PRBM will be completed during the Upper Salmon Basin Hydrologic Monitoring and Analyses III project.

The remaining steps to PRBM completion include:

1) Rainfall-runoff modeling to estimate catchment runoff
2) Update the PRBM network. The POD-POU system was developed in 2007 for the 2008 release. This system may have changed in the intervening years; thus, a review is necessary to reflect current conditions.
3) Populate the water user node timeseries with water demand and return flow timeseries. The MS Excel workbooks that store and calculate this information, including consumption and return lag, will need to be populated with Pahsimeroi data. Similar to the LRBM, a Data Atlas will be developed to catalog salient information for each POD-POU, including water user rights, irrigation practices, and typical diversion and consumptive rates.
4) Estimate reach gains and losses between river nodes using gaged streamflow, tributary inflows, and diversion records.
5) Conduct water balance checks and compare simulated reach gains and losses to available reach gain surveys to support initial calibration.
6) Documentation of the model.

Completion of these additional development steps will allow the PRBM to be used for evaluating basin conditions, habitat improvement projects, and water management alternatives.

Task 8 – Intensely monitored study site near the confluence of the Mainstem Lemhi River and Lower Hayden Creek

Hydrogeologic data collection near the confluence of the Lemhi River and Hayden Creek

Streamflow data were collected at three stream gages within six miles of the confluence of the Lemhi River and Hayden Creek (Table 8, Figure 20). The Hayden Creek gage, located approximately 0.2 miles upstream of the confluence with the Lemhi River, was operated using PCSRF funds. In cooperation with IDWR, the USGS maintained two additional gages, the Lemhi River nr McFarland (5.52 miles upstream of the confluence) and the Lemhi River nr Lemhi (4.87 miles downstream of the confluence). The gages on the Lemhi River bracket the confluence area and allow for evaluation of changes to flow across the study site. Streamflow records for the Hayden Creek gage are available through the IDWR streamflow data portal (Aqua Info), and records for the Lemhi River gages are provided by the USGS through the National Water Information System (NWIS).

Surface water quality data were collected at all three stream gages, as well as at a Lemhi River site approximately 0.27 miles upstream of the confluence, and a site near the mouth of Little Sawmill Creek, which is a tributary to the Lemhi River. Surface water quality data collected as part of this project will be made available through the IDWR Upper Salmon Hydrologic Project site (https://idwr.idaho.gov/water-data/projects/upper-salmon/references/). Periodic field measurements (Table 4 for frequency) included temperature, pH, dissolved oxygen (DO), specific conductivity (SC), and turbidity. Grab samples were collected for laboratory analysis of ammonia as nitrogen (NH_3-N), total nitrogen (TN), total phosphorus (TP), total suspended solids (TSS), total coliform, and Escherichia coli (E. coli).

Surface water and groundwater systems are strongly interconnected in this reach of the Lemhi River. The alluvial aquifer narrows to approximately 20 feet thick and 3,300 feet wide (Figure 20, Upper-Lower

Basin Divide), conditions that are likely to promote substantial groundwater discharge to the Lemhi River (Donato, 1998). As a result, groundwater monitoring is critical to understanding streamflow dynamics and water quality patterns in the confluence area. These groundwater data support assessment of hydraulic gradients, groundwater contributions to streamflow, and potential nutrient transport pathways to surface water.

IDWR continuously monitored groundwater levels at nine wells within six miles of the confluence. Groundwater quality was evaluated at two wells as part of IDWR's Statewide Groundwater Quality Monitoring Program, including one located approximately 1.58 miles upstream of the confluence, and one located approximately 4.54 miles downstream of the confluence. Well number 18N 24E 33BAC1 was last visited in 2023, and samples were assessed for 25 analytes, including DO, Nitrate and Nitrite as N, pH, SC, and water temperature, which can be compared to the lab results for surface water samples. Well number 19N 24E 32ACB1 was last visited in 2017; however, it is typically sampled for water quality approximately once every five years and is scheduled for another sampling event in 2026. Analysis of groundwater quality is outside of the scope of this report but will be included in future analyses.

Table 8. Monitoring sites within six miles of the Lemhi River and Hayden Creek confluence

Site Name	Site Type	Position	Distance to Confluence (mi)
17N 24E 13CBD1	Groundwater Levels	Upstream	5.90
Lemhi River nr McFarland	Streamflow, Surface Water Quality	Upstream	5.52
18N 24E 33ACB1	Groundwater Levels	Upstream	2.76
18N 24E 31ACD1	Groundwater Levels	Hayden Creek	1.96
17N 24E 04ADC1	Groundwater Levels	Upstream	1.77
18N 24E 33BAC1	Groundwater Quality	Upstream	1.58
Little Sawmill Creek at Hwy 28	Surface Water Quality	Upstream	1.48
Lemhi River ab Hayden Creek	Surface Water Quality	Upstream	0.27
Hayden Creek	Streamflow, Surface Water Quality	Hayden Creek	0.20
18N 24E 21BCD1	Groundwater Levels	Downstream	0.44
18N 24E 20ADD1	Groundwater Levels	Downstream	0.50
19N 24E 32ADC1	Groundwater Levels	Downstream	4.44
19N 24E 32ACB1	Groundwater Quality	Downstream	4.54
Lemhi River nr Lemhi	Streamflow, Surface Water Quality	Downstream	4.87
19N 24E 29BDA1	Groundwater Levels	Downstream	5.65
19N 24E 30AAA2	Groundwater Levels	Downstream	6.00

Analysis of hydrogeologic data collected near the confluence of the Lemhi River and Hayden Creek

This task was initiated during the current project and is intended to continue through completion of planned habitat improvement work and the subsequent stabilization period. IDWR will characterize hydrogeologic conditions in the project area before, during, and after habitat implementation. Simultaneously, the Idaho Department of Fish and Game will monitor fish migration and redd distribution in the same reach. Characterization of streamflow, groundwater and surface water interactions, and water quality will support interpretation of salmonid monitoring data and evaluation of the effectiveness of habitat improvements in achieving project goals.

According to Gavin Aguilar and Justin Saydell (Tech Team, personal communication, February 27, 2026), implementation of habitat improvement projects near the Lemhi River and Hayden Creek confluence began in 2021, with the Henry Reach Phase 1 project. Additional projects continued habitat improvement work in 2024 and 2025, with new projects potentially breaking ground in 2026 and 2027 (Figure 20). Because limited habitat improvement work occurred prior to 2025 and implementation remains ongoing, this report focuses on characterization of baseline, pre-project hydrogeologic conditions in the confluence area. Characterizing baseline conditions provides hydrologic context for ongoing salmonid monitoring efforts and supports future evaluation of habitat project efficacy in achieving salmonid recovery goals.

Baseline streamflow of the Lemhi River and Hayden Creek confluence area

Daily streamflow hydrographs for the Lemhi River nr McFarland, Hayden Creek, and the Lemhi River nr Lemhi (see Figure 20 for locations) illustrate baseline surface water conditions in the confluence reach during water years 2011 through 2020 (Figure 21). Streamflow at the Lemhi River nr McFarland Gage reflects Upper Lemhi Basin hydrologic variability, while Hayden Creek exhibits a more rapid and pronounced response to runoff events typical of a smaller tributary system. Streamflow at the Lemhi River nr Lemhi Gage integrates upper basin flows with the tributary inflows from Hayden Creek and Little Sawmill Creek (ungaged). These hydrographs illustrate the differences of magnitude, timing, and seasonal variability of streamflow near the confluence.

To further characterize baseline conditions, streamflow statistics were computed for each gage (Table 9) to summarize typical flow magnitude, variability, and timing. These metrics provide a basis for comparison among sites and establish reference conditions for evaluating hydrologic changes associated with habitat project implementation.

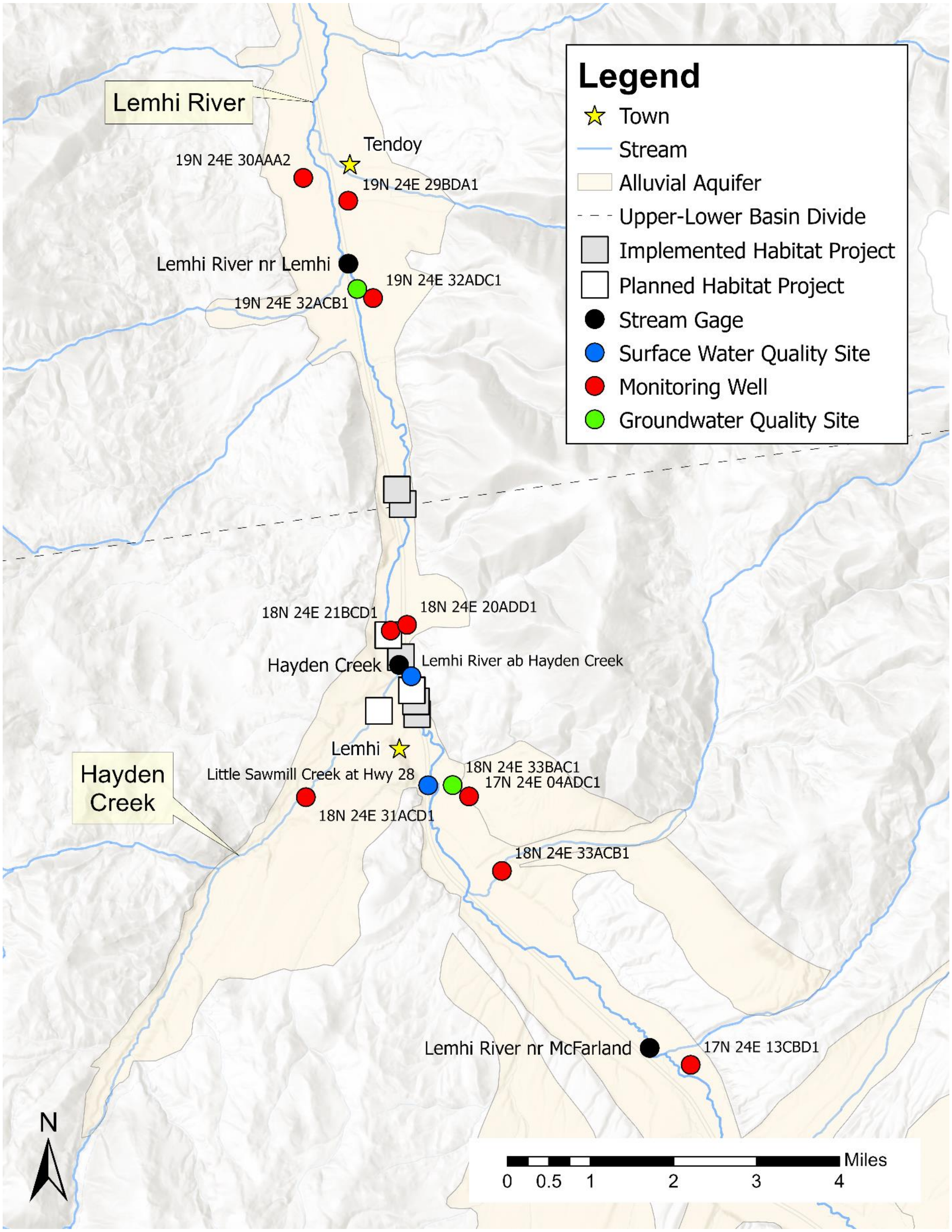


Figure 20. Monitoring sites within six miles of the Hayden Creek and Lemhi River confluence

Streamflow statistics were calculated using daily mean discharge for the April–October period from 2011 through 2020. This seasonal window minimizes the influence of winter icing and data gaps. For each gage, summary statistics were computed only for years with at least 90 percent data coverage. Due to data limitations, analyses for the Lemhi River near McFarland gage include seven years of record, while analyses for the remaining gages include data from each year from 2011 through 2020.

Typical streamflow conditions were characterized using median-based metrics. Median April–October discharge was calculated for each year and then summarized across the period of record to represent typical flow conditions. Low-flow and high-flow conditions were characterized using the median of annual minimum and annual maximum daily discharge, respectively, computed by first identifying the minimum and maximum daily flows in each year and then summarizing those values across the analysis period.

Streamflow timing was characterized by calculating the median day of the year corresponding to 50% of cumulative April-October flow at each gage. Together, these streamflow magnitude and timing metrics provide a framework for comparing streamflow conditions across gages, establishing baseline conditions prior to habitat project implementation, and supporting future evaluation of habitat improvement project efficacy.

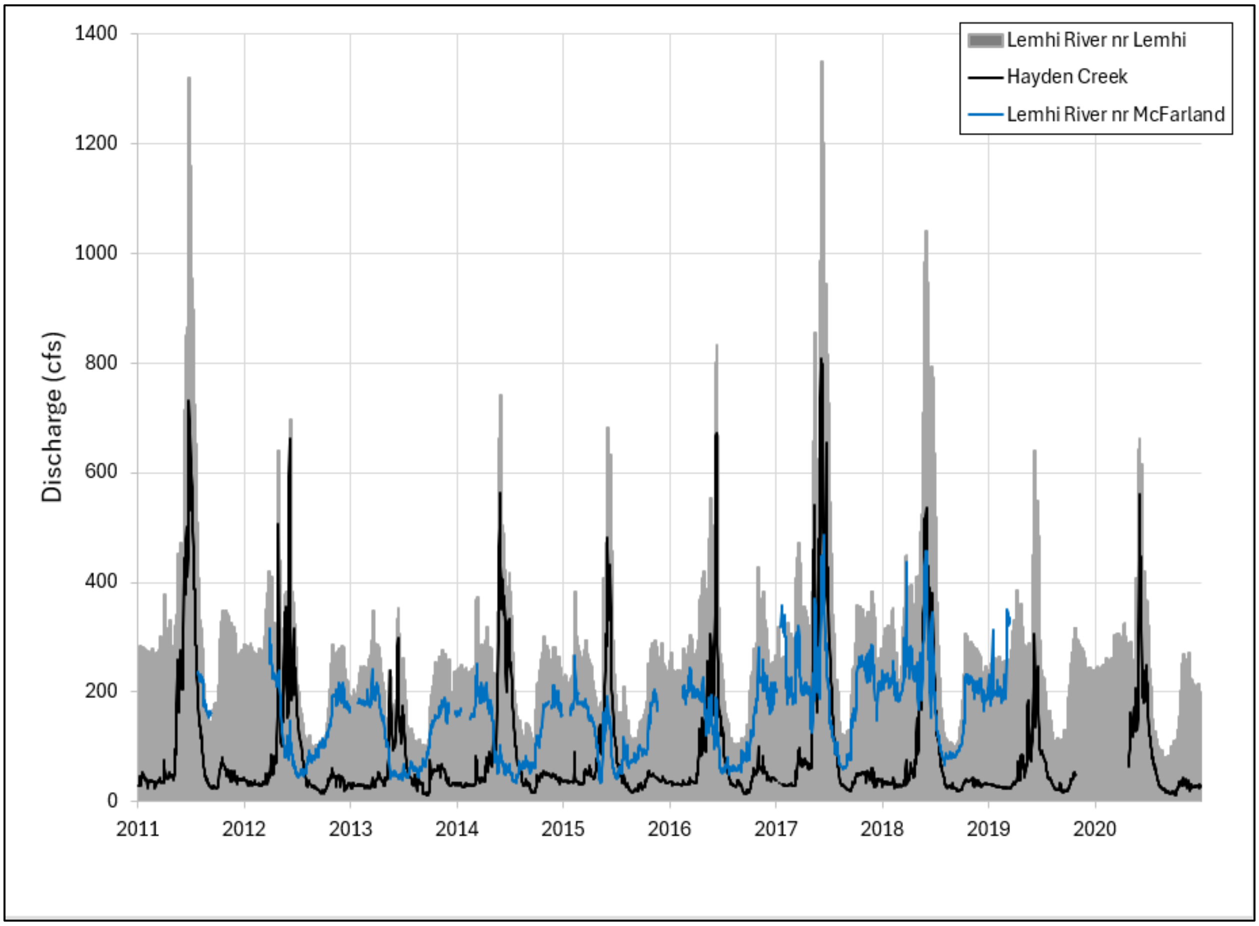


Figure 21. Baseline streamflow in the Lemhi River and Hayden Creek confluence area (2011-2020)

Table 9. Baseline April 1-October 31 streamflow statistics for gages near the Lemhi River and Hayden Creek confluence (2011-2020)

Stream Gage	n	Median Annual Flow (cfs)	Median Annual Min (cfs)	Median Annual Max (cfs)	Median DOY (50% cumulative flow)
Lemhi nr McFarland	7	98.4	43.7	282	06/19
Hayden Creek	10	50.3	16.3	550	06/04
Lemhi nr Lemhi	10	220	94.1	719	06/15

Baseline groundwater levels within six miles of the Lemhi River and Hayden Creek confluence

Groundwater level summary statistics were computed for monitoring wells near the Lemhi River and Hayden Creek confluence using depth to water (DTW) measurements collected from 2011 to 2020 (Table 10). Due to greater data availability, groundwater level statistics were computed using year-round records, thereby incorporating any lagged groundwater responses into the analysis.

Prior to analysis, annual records were screened to remove pumping effects, improve data completeness, and ensure consistency amongst wells. First, groundwater level data was screened for notes on pumping and data spikes of ten feet or more. Next, the shallowest daily groundwater level was selected for each day that contained two or more measurements. Lastly, only years with water level observations during at least 90% of days were included in the analysis. As a result of this screening process and varying periods of record, the number of years contributing to statistics varies by well (Table 10).

To characterize baseline groundwater conditions, median DTW was calculated across qualifying years for each well. Seasonal extremes were evaluated by computing the median annual minimum and maximum DTW. Seasonal timing was characterized by calculating the median day of year corresponding to the deepest and shallowest DTW readings. Together, these DTW and groundwater timing metrics provide a framework for comparing groundwater levels across wells. Table 10 establishes baseline conditions prior to habitat implementation and establishes a reference point for assessing the impacts of habitat improvement activities.

Table 10. Baseline groundwater level statistics for wells near the Lemhi River-Hayden Creek confluence (2011-2020)

Well ID	n	Median DTW (ft)	Median Annual Max DTW (ft)	Median Annual Min DTW (ft)	Max DOY	Min DOY
17N 24E 04ADC1	8	19.56	22.07	5.58	02/28	06/15
17N 24E 13CBD1	6	19.43	19.99	6.02	12/10	07/19
18N 24E 20ADD1	10	12.54	28.63	3.36	03/10	06/09
18N 24E 21BCD1	6	23.13	39.68	12.14	03/09	06/15
18N 24E 31ACD1	6	19.09	23.86	3.91	04/06	06/23
18N 24E 33ACB1	6	77.79	85.91	70.09	05/13	08/10
19N 24E 29BDA1	6	14.89	16.85	11.20	03/29	07/01
19N 24E 30AAA2	6	18.26	25.66	12.46	03/05	09/17
19N 24E 32ADC1	8	12.25	16.47	2.04	03/29	06/04

Baseline groundwater levels for each well were plotted by individual year to characterize interannual and seasonal variability (Figure 22). Most wells in this reach exhibit a consistent annual pattern, with groundwater levels rising rapidly in late April through May, peaking between May and July, declining through late summer, showing a minor increase in September to October, and continuing to decline through the remainder of the year.

The rapid increase in groundwater levels during late April and May likely reflects a combination of recharge processes associated with both irrigation practices and seasonal hydrologic conditions. The onset of irrigation introduces recharge to the aquifer through diversion ditches and field application, with a portion of ditch flow and applied water returning to the aquifer as deep percolation. Concurrently, spring snowmelt elevates river stage, which increases hydraulic gradients between the river and adjacent aquifer where river stage rises more rapidly than nearby groundwater that is hydraulically connected to the river. This promotes aquifer recharge via streambed seepage. Low-elevation snowmelt and spring precipitation may provide additional recharge, although these inputs are likely secondary relative to irrigation and river-driven processes.

Peak groundwater levels, typically observed between May and early July, coincide with maximum irrigation activity and peak streamflow in the Lemhi River and its tributaries. During this period, river stages may exceed bank elevation, resulting in overbank flow and floodplain saturation. Groundwater levels during this period likely reflect a combination of recharge from diversion ditch seepage, field application, and increased streambed and floodplain seepage, along with delayed contributions from higher-elevation snowmelt and irrigation return flow.

Following peak conditions, groundwater levels decline gradually through July and August, coinciding with increasing evapotranspiration and rapidly decreasing stream stage. The increased evapotranspiration likely results in lesser aquifer recharge from diversion ditches and field application. In addition, Lemhi River seepage investigations conducted in August (Donato, 1998; CH2M HILL, 2014) indicate that this reach gained approximately 8 to 14 cfs, suggesting a net discharge of groundwater to the river under late-summer conditions. This behavior is consistent with groundwater levels remaining elevated from irrigation practices, such that groundwater levels decline more slowly than river stage. Under these conditions, hydraulic gradients may increase from the aquifer toward the river, supporting groundwater discharge to the stream channel.

Most wells show a minor increase in groundwater levels during the September to October timeframe. This pattern may reflect reduced evapotranspiration associated with cooler temperatures, seasonal changes to agricultural practices, and increased precipitation relative to the preceding months. Harvest typically occurs in late August through early September in the Lemhi Basin, which is likely to reduce crop water use; however, irrigation continues after harvest in some areas to maintain soil moisture. Seepage investigations (Donato, 1998; CH2M HILL, 2014) indicate that this reach sometimes transitions to a losing condition (−4 to −22 cfs) during October, which may contribute to the observed increase in groundwater levels in areas that have strong hydraulic connectivity to the river.

From October through the end of the year, groundwater levels decline steadily as the irrigation season ends and recharge inputs diminish. During this period, groundwater levels generally return toward non-irrigation season conditions. Inspecting Figure 22 further, it is noteworthy that groundwater levels typically stabilize or continue to slowly decline through March to early April of the next year, with the irrigation season typically starting in mid-April.

One well, 19N 24E 30AAA2, exhibits a distinct pattern relative to the other wells. Water levels differ significantly year-to-year, the April to May increase in water levels is muted relative to other wells, and peak water levels are not observed until September. Further study is needed to determine why water level fluctuations differ significantly at this location. Overall, variability in the timing of groundwater level fluctuations among wells likely reflects differences in aquifer recharge pathways, travel times, and the degree of hydraulic connectivity to the Lemhi River, tributaries, and irrigation infrastructure.

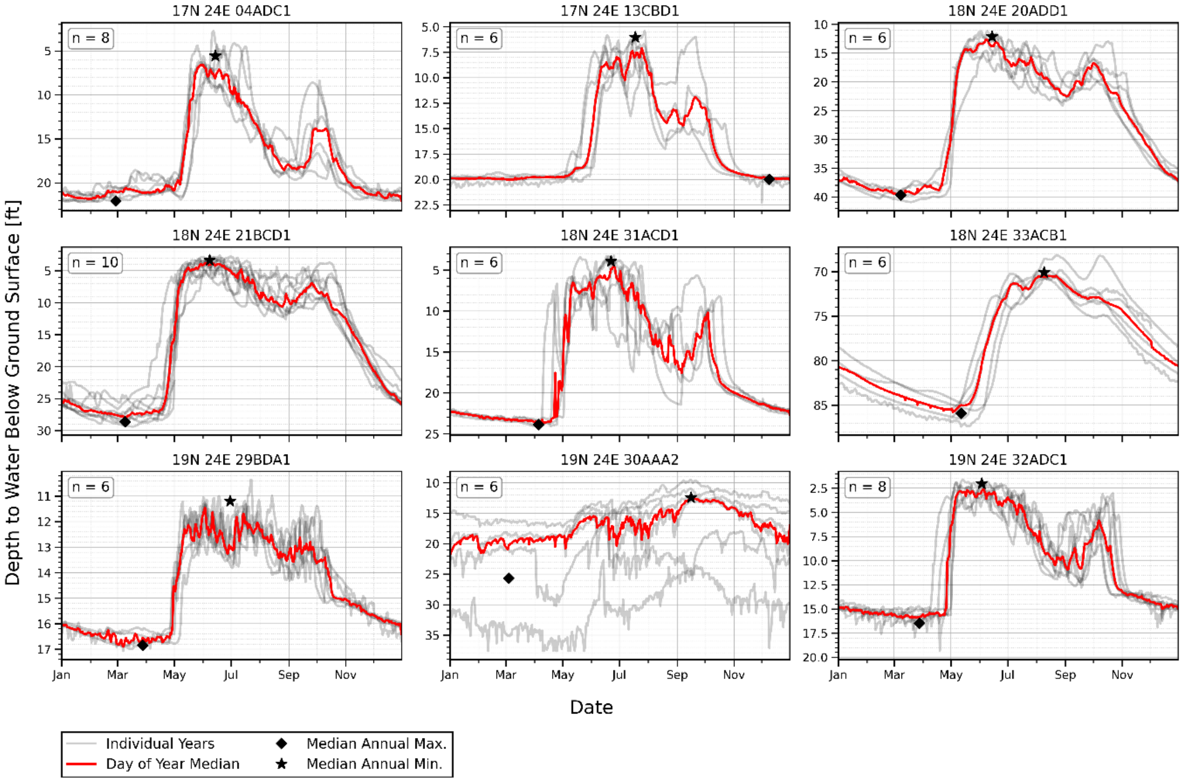


Figure 22. Annual hydrographs for wells near the Lemhi-Hayden Creek confluence (2011-2020)

Baseline surface water quality within six miles of the Lemhi River and Hayden Creek confluence

Surface water quality data were collected to characterize typical conditions in the Lemhi River and Hayden Creek confluence reach prior to substantial habitat modification. Surface water quality data was collected in this reach in 2020 – 2021 and 2023 – 2024. Although some surface-water quality data were collected after initial habitat project implementation began in 2021, as of 2024, substantial channel modification had not yet occurred upstream of any sites except for the Lemhi River nr Lemhi Gage. As a result, data from all sites except the Lemhi River nr Lemhi may be considered representative of baseline conditions.

Median surface water quality field parameter values for all site visits from 2020 through 2024 are described in Table 11. From 2020 through 2024, Lemhi Basin water quality monitoring campaigns were conducted once during the winter, twice in the fall, three times in the spring, and five times in the summer. Each site within six miles of the Lemhi River and Hayden Creek confluence was visited at least eight times in total from 2020 through 2024 (Table 11).

For context when viewing Table 11, DO concentrations above 9.75 mg/L are considered optimal, while 8 - 9.75 mg/L is considered suitable for incubating salmonid eggs, which is the most sensitive life stage to DO levels (Carter, 2008). Optimal temperatures are defined as 7.2 - 14.5°C from April to September and 5 – 11°C from October through March, with sustained temperatures above 18°C or below 4.5°C considered poor conditions for all life stages (Carter, 2008). pH values of 7 to 8 are considered optimal, and 8 to 9 are considered suitable (Muan and Moulton, 2011). Lastly, turbidity less than 20 NTUs is considered optimal for salmonid visibility.

Viewing Table 11 through this context, median values at every site fall within the optimal or suitable water quality ranges. Despite conditions being suitable on average, it is noteworthy that minimum and maximum values recorded at several sites fell outside of the optimal to suitable range. For example, turbidity was observed well above 20 NTU at four sites, typically during spring runoff. Additionally, in the summer, water temperatures often exceeded suitable levels and DO was often below optimal concentrations. Lastly, max pH readings at three sites exceeded 8.75, which is on the maximum side of suitable conditions. These results suggest that opportunities may exist to improve water quality conditions for salmonids in this reach. See IDWR (2022) for further details on optimal water quality field parameters for various salmonid life stages, as well as seasonal variability of collected water quality data.

Table 11. Median baseline surface water quality conditions for sites near the Lemhi River-Hayden Creek confluence from 2020 through 2024. Ranges of values collected are shown in parentheses.

Site Name	n	Temp (°C)	DO (mg/L)	pH	Turbidity (NTU)
Lemhi River nr McFarland Gage	10	12.4 (0.3–17.4)	9.8 (8.4–12.2)	8.54 (8.19–8.96)	6.3 (0.0–60.9)
Little Sawmill Creek at 28	9	11.1 (5.7–17.0)	9.4 (7.9–12.5)	8.23 (7.88–8.45)	11.6 (0.0–209)
Lemhi River ab Hayden Creek	8	11.1 (1.6–15.7)	9.6 (8.8–11.9)	8.48 (8.02–8.83)	6.3 (0.1–18.2)
Hayden Creek Gage	8	12.7 (2.6–14.9)	8.7 (8.2–11.0)	8.25 (7.47–8.65)	0.0 (0.0–29.7)
Lemhi River nr Lemhi Gage	10	11.4 (1.6–16.0)	9.4 (8.1–11.5)	8.48 (7.51–8.77)	5.0 (0.0–30.8)

In addition to spot water temperature measurements, Hayden Creek and the Lemhi River nr McFarland Gage were equipped with data loggers that recorded temperature in addition to stage during part of the period of record, with data recorded at the Lemhi nr McFarland gage from 2011 to 2017 and at the Hayden Creek gage from 2016 to present (Figure 23). The red lines on Figure 23 indicate temperature thresholds for suitable conditions (5 – 14.5°C), and the black lines indicate temperature thresholds for optimal conditions.

The Lemhi River nr McFarland Gage often exceeded the suitable range of temperatures during the summer and fell below it during the winter. It is also noteworthy that the Lemhi at McFarland recorded temperatures below -15°C every winter. Temperatures below 0°C were not plotted in Figure 23 because temperatures well below 0°C most likely represent the temperature of ice, rather than liquid water, as this gaging site was known to freeze over during the winter months. In contrast, water temperature at the Hayden Creek Gage rarely exceeded the suitable range but typically fell below it periodically each winter. Also, unlike the McFarland Gage, Hayden Creek Gage remained above 0°C throughout the period of record. The water temperature data at both gages suggests that there is a need for temperature refugia in this reach to ensure optimal growth and survival of salmonids.

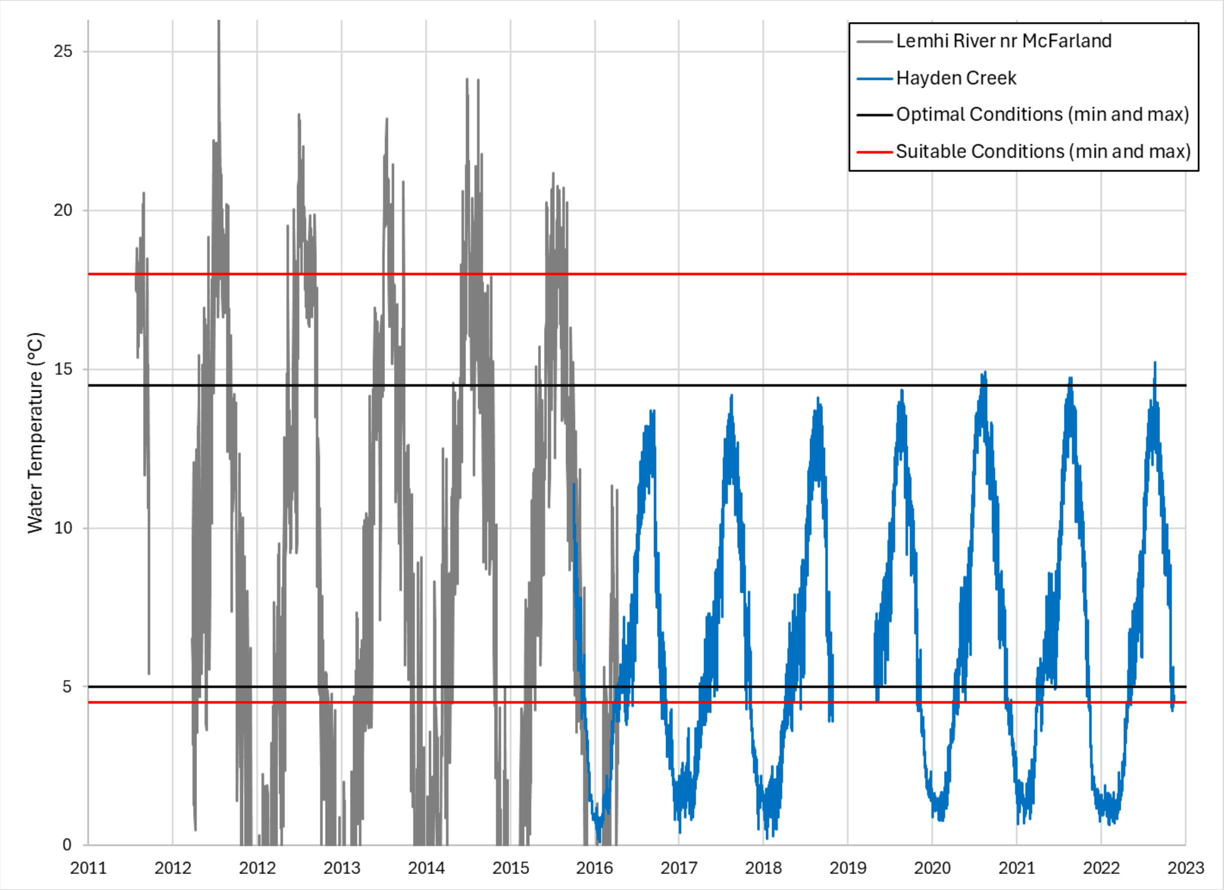


Figure 23. Surface water temperature at the Lemhi River nr McFarland and Hayden Creek gages

Lastly, in addition to water quality field parameter and stream gage data, IDWR also collected grab samples for laboratory analyses at all five water quality sites within six miles of the Lemhi River and Hayden Creek confluence (Table 12).

Table 12. Baseline surface water quality lab analyses for sites near the Lemhi River-Hayden Creek confluence

Site Name	Date	NH_3 (mg/L)	NO_3-NO_2 (mg/L)	Total P (mg/L)	TSS (mg/L)	Coliform (MPN/100ml)	E. Coli (MPN/100ml)
Lemhi River nr McFarland	9/12/24	<0.05	0.21	0.05	6.5	2600	540
	5/17/24	<0.05	0.23	0.14	30	>2420	980
Little Sawmill Creek at Hwy 28	10/12/23	0.03	0.29	0.08	<5	1986	166
	6/7/24	<0.05	0.25	0.26	110	>2420	>2420
Lemhi River ab Hayden Creek	10/12/23	<0.05	0.23	0.05	5.0	>2420	59
	5/17/24	<0.05	0.21	0.12	NA	>2420	613
	9/12/24	<0.05	0.23	0.07	6	2280	380
Hayden Creek	10/12/23	0.03	<0.01	0.06	13	1120	56
	5/17/24	<0.05	0.09	0.14	53	921	162

Site Name	Date	NH_3 (mg/L)	NO_3-NO_2 (mg/L)	Total P (mg/L)	TSS (mg/L)	Coliform (MPN/100ml)	E. Coli (MPN/100ml)
Lemhi River nr Lemhi	10/12/23	<0.05	0.16	0.05	7.0	>2420	249
	5/17/24	<0.05	0.12	0.14	50	1733	313
	9/12/24	<0.05	0.16	0.06	6.0	2050	290

Reviewing the water quality lab analyses, all NH_3 and NO_3-NO_2 levels are at very low to moderate levels and are not a direct concern for salmonid habitat quality. Interestingly, however, total phosphorus levels are above ideal conditions. EPA nutrient ecoregion guidance for the Western Mountains suggests that total phosphorus concentrations below approximately 0.05 mg/L are representative of reference conditions, whereas concentrations approaching or exceeding 0.10 mg/L are associated with increased risk of eutrophication and dissolved oxygen depletion (EPA, 2000). The Total P reading of 0.26 mg/L at Little Sawmill Creek in June 2024 is particularly notable, as, despite it being a small tributary, with likely spring flows of 15-20 cfs (visual observation), its outflows may have been increasing phosphorus levels in the Lemhi River at this time.

Evaluating total suspended solids (TSS), levels exceeding 50 mg/L can stress juvenile salmonids and levels exceeding 100 mg/L can impair feeding and gill function (Newcombe and Jensen, 1996). Furthermore, fine sediment negatively impacts redd survival rates (Chapman, 1988). During the May and June sampling events, TSS levels exceeding 50 mg/L were observed at Little Sawmill Creek, Hayden Creek, and the Lemhi River nr Lemhi. Due to a sampling error, a sample collected at the Lemhi River ab Hayden Creek was unable to be processed. With a TSS reading of 110 mg/L, Little Sawmill Creek had fine sediment levels that would impair feeding and gill function at this time. Hayden Creek had higher TSS than the Lemhi River nr McFarland, likely contributing to the elevated TSS at the Lemhi River nr Lemhi gage compared to the Lemhi River nr McFarland gage.

Task 9 – Evaluation of the impacts of the Beaver Dam Analogues on Hawley Creek

This task could not be completed due to the absence of relevant data. All fully functioning beaver dam analogues (BDAs) were manipulated due to the drying of Hawley Creek during the 2021 drought, and none of the BDAs were repaired or replaced during this project period. As a result of the BDAs being manipulated, there is no new data available to evaluate the hydrologic impacts of the beaver dam analogues. See the IDWR (2023) report for soil water tension data adjacent to the beaver dam analogues, as well as data analyses.

Task 10 – Evaluation of the hydrologic impacts of stream channel migration and changes to irrigation practices in the Pratt Creek Drainage

IDWR began monitoring streamflow, groundwater levels, and soil moisture tension in the Pratt Creek drainage in 2016. Following installation of this monitoring network, irrigation of the local agricultural fields was changed from flood to sprinkler irrigation prior to the 2017 irrigation season and a 0.34 mile section of the Pratt Creek stream channel was migrated in fall 2018 as part of a habitat improvement project (Pratt Creek Channel Rehabilitation). IDWR evaluated the collected data and characterized the changes to local hydrogeology that occurred since these projects were implemented. The Pratt Creek drainage monitoring sites, channel migration, and agricultural fields are detailed in Figure 24.

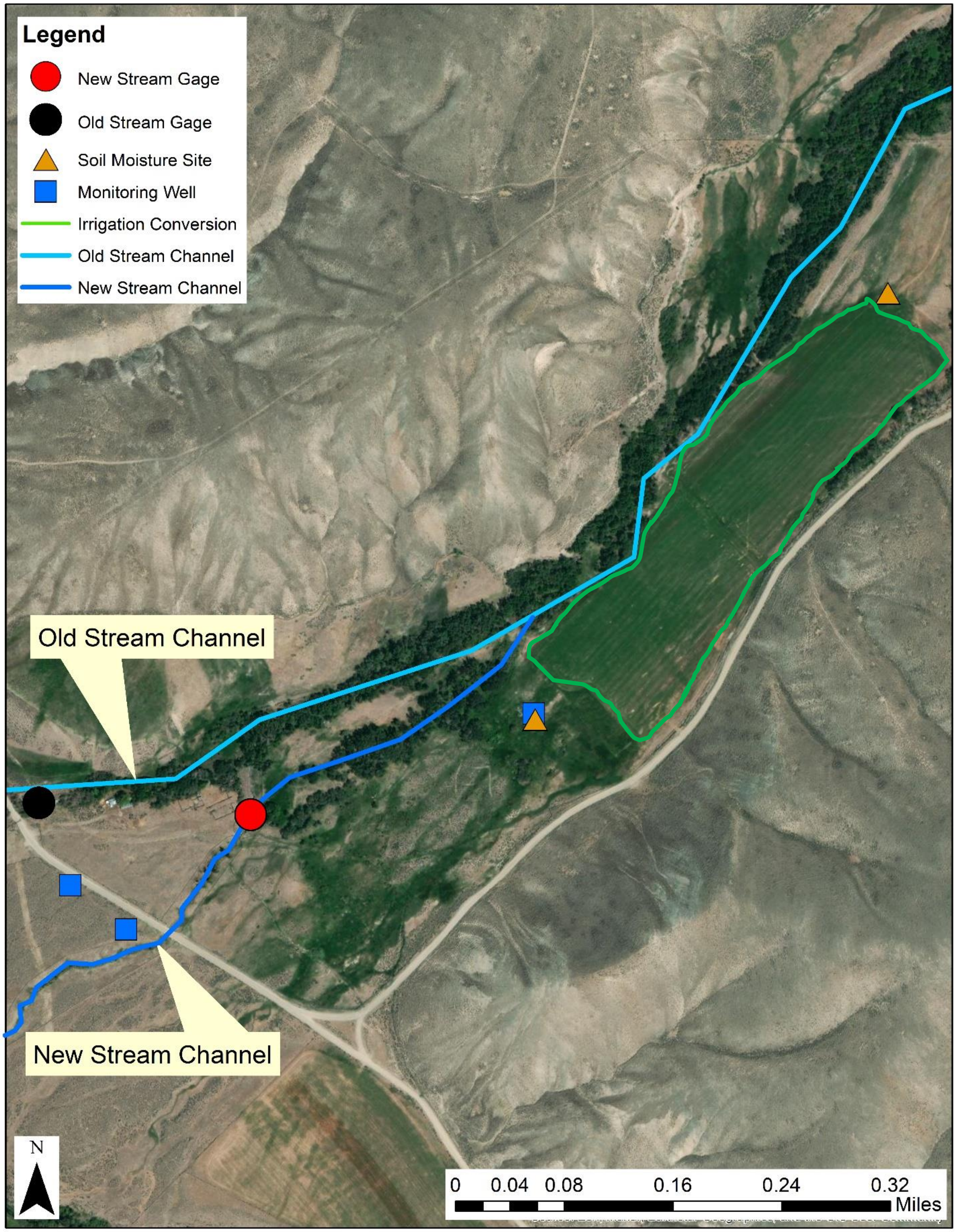


Figure 24. Pratt Creek drainage, stream channel migration, places of use, and monitoring sites

Before evaluating the hydrologic monitoring data, it is important to note that climate in the Pratt Creek drainage, as well as in the larger Lemhi Basin, has resulted in frequent drought conditions from 2021 to present (Drought.gov). Of note is a prolonged exceptional drought in late 2021. Interpretation of changes to streamflow, groundwater levels, and soil moisture following project implementation should consider these drought conditions occurring in the second half of the period of record, while conditions from 2016 through 2020 were comparatively colder and wetter, with only a few short droughts of moderate severity.

A hydrograph was created to compare investigate streamflow following channel migration and conversion from flood to sprinkler irrigation (Figure 25). The gap in the period of record that began in late 2018 and ended in early 2020 was a result of both the stream channel and the stream gage being migrated. The spike in streamflow in early 2020 was characteristic of Lemhi River tributaries in this part of the basin; in addition to Pratt Creek, both Bohannon Creek Lower and Kenney Creek showed peak 2020 flows higher than peak flows in 2017-2018 (see Aqua Info for data for other stream gages). The downtrend in Pratt Creek peak annual flows is noteworthy, but again, both Bohannon Creek Lower and Kenney Creek show a similar trend.

The Pratt Creek minimum streamflow in water year 2021 was lower than at any other point in the period of record, dipping to 0.33 cfs. However, similarly, Bohannon Creek Lower also had its lowest minimum streamflow value in the 2016 to 2025 period that year, dipping to 0.75 cfs. It is typical for recently migrated stream channels to lose more flow to seepage during conveyance, and it is possible that the low flows in Pratt Creek following project implementation were caused, at least in part, by elevated streambed seepage during the post-project stabilization period. The groundwater level data collected from the wells adjacent to the migrated channel was evaluated to investigate any changes to the local groundwater system (Figure 26).

Monitoring well 20N 23E 11ADD2 is located just downgradient of an agricultural field that was converted from flood to sprinkler irrigation prior to the 2017 irrigation season. Minimum DTW values appear to have declined from water year 2017 through water year 2019, with this trend continuing, albeit with very minor decline, in water years 2021 through 2024. Overall, from water year 2017 to water year 2024, there has been a decline in minimum DTW of approximately two feet. This decline may reflect reduced aquifer recharge following conversion from flood to sprinkler irrigation. The maximum DTW has remained relatively stable throughout the period of record.

Monitoring wells 20N 23E 11DBB1 and 20N 23E 11DBB2 are located adjacent to the migrated Pratt Creek stream channel, with the former being located approximately 100 feet from the new stream channel, and the latter being located approximately 400 feet from the new stream channel, and about halfway between the old channel and new channel. Both wells show a trend of consistently declining annual minimum, maximum, and median groundwater levels following channel migration in fall 2018 and continuing until the end of water year 2022, with some stabilization in water years 2023 and 2024. The water level stabilization in 2023 to 2024 could be the result of changes to climate (less drought), stabilization of the aquifer following implementation of the Pratt Creek projects, or both.

Water years 2019 and 2020 are noteworthy, because maximum DTW became shallower by three to four feet at both wells relative to water years 2017 and 2018. Following water year 2020, the annual deepest water levels gradually declined, with these values returning to within one to two feet of the baseline conditions in water years 2017 and 2018. This could be evidence of the migrated stream channel allowing for greater seepage soon after project implementation, followed by decreased stream channel seepage in subsequent years as the streambed approaches conditions nearer to those that existed in the old stream channel. It is unlikely that these changes to groundwater level dynamics were brought on by the shift from flood to sprinkler irrigation further up the drainage, as monitoring well 20N 23E 11ADD2 did not exhibit similar trends. It is, however, possible that the switch from flood to sprinkler irrigation contributed to the decrease in magnitude between annual minimum and maximum DTW values, but the frequent drought conditions in water year 2021 and beyond may have also played a role in this trend.

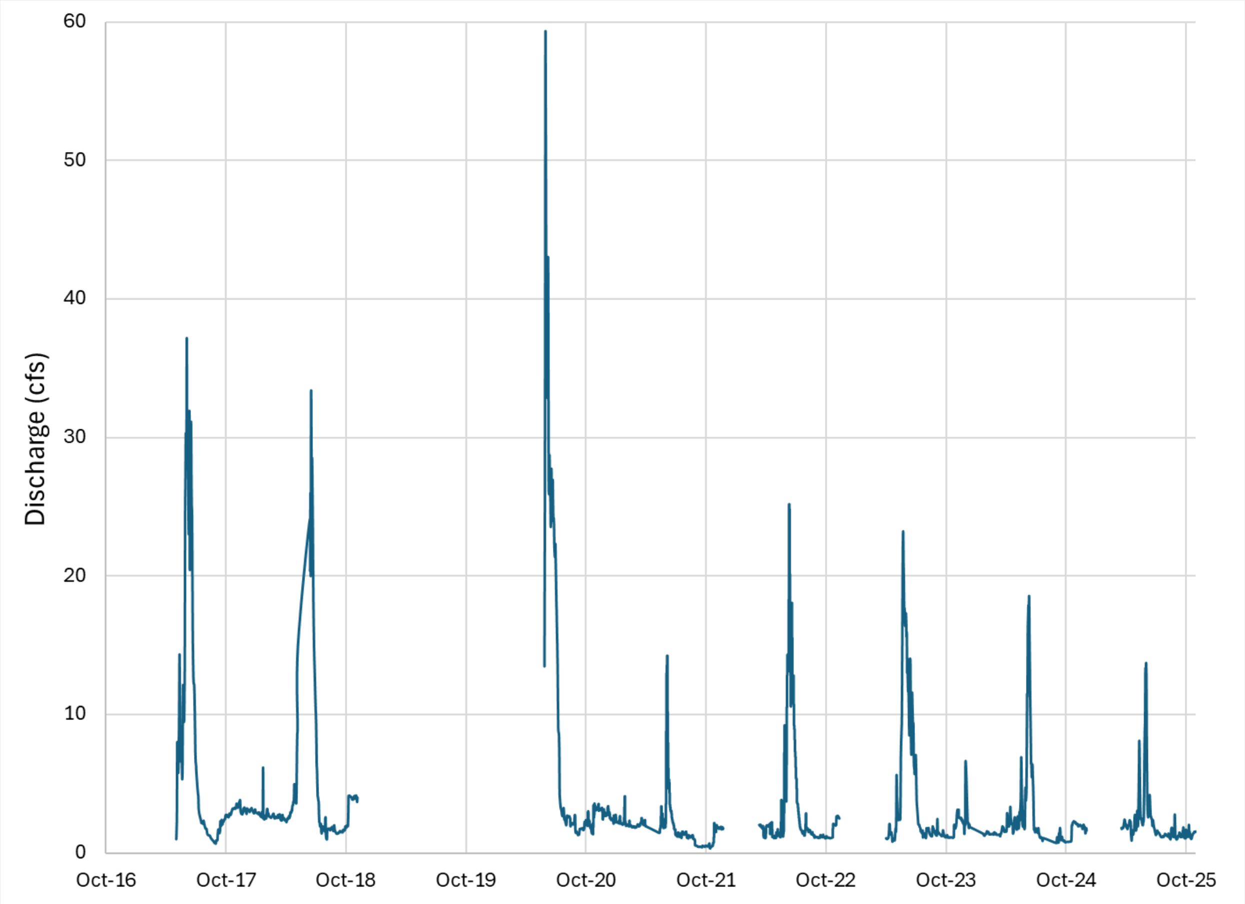


Figure 25. Pratt Creek streamflow from water year 2017 through 2025

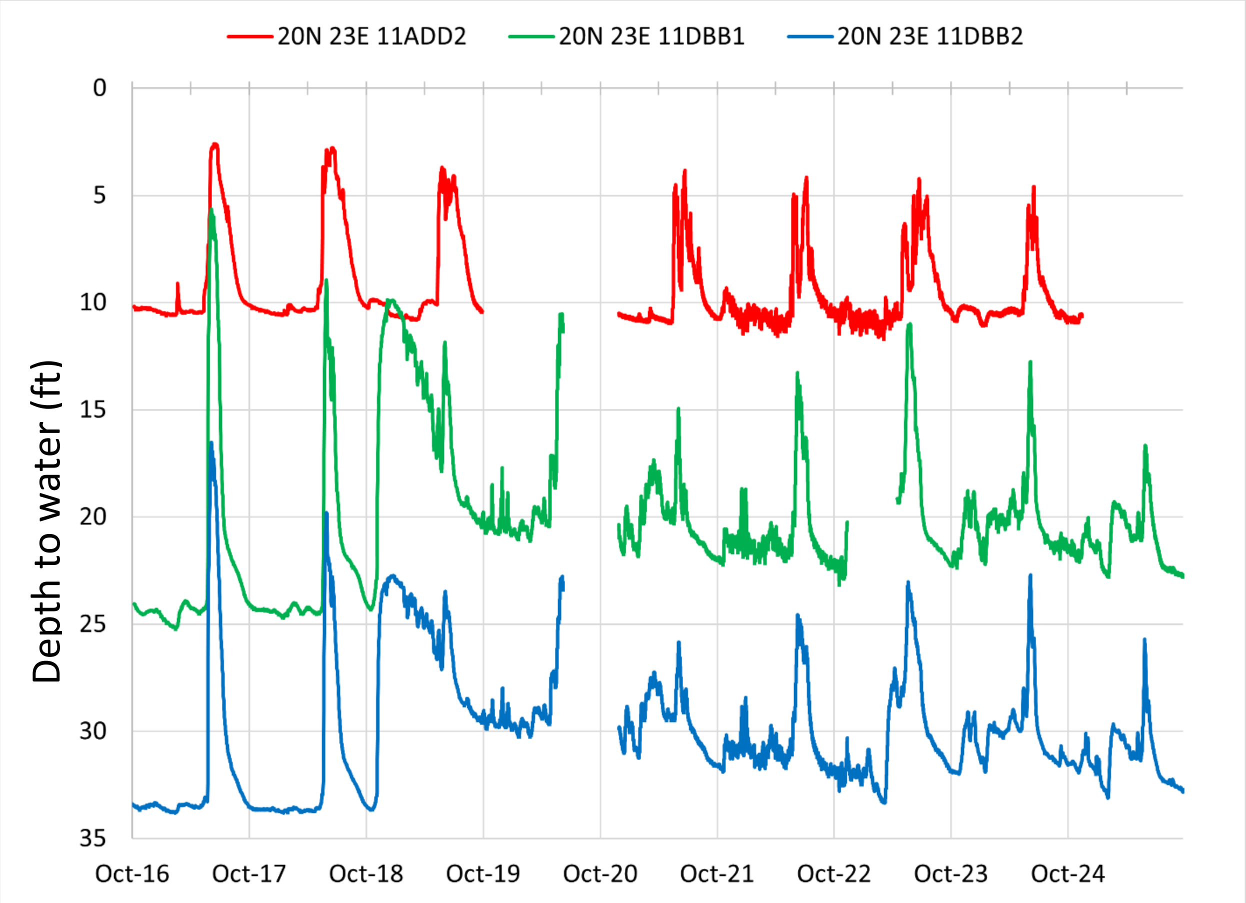


Figure 26. Pratt Creek drainage monitoring well depth to water data from water year 2017 to 2025

Data from the soil water tension site near well 20N 23E 11ADD2 was plotted in Figure 27 in an effort to further evaluate changes to infiltration dynamics following the conversion from flood to sprinkler irrigation prior to the 2017 irrigation season. This site is located just down-gradient of the agricultural fields where the conversion occurred. The data gaps make the data difficult to interpret; however, the available data is evaluated.

In the one year of data collected prior to the shift from flood to sprinkler irrigation, soil water tension remained below the wilting point at the one-foot depth all year, and the three- and even five-foot depth sensors only briefly spiked above the wilting point. Following the switch from flood to sprinkler irrigation, it is common for the soil water tensiometers at one, three, and five feet depth to show soil water tension above the wilting point for much of the irrigation season. The five-foot depth is often very dry relative to the wilting point. These results are unlikely to be caused by drought alone, as drought did not occur in 2019, 2020, or 2023. Assuming the increasingly persistent drying of the soil column at one, three, and five feet depth was not caused by drought alone, these results suggest that conversion from flood to sprinkler irrigation led to less infiltration of irrigation water into the deep soil column. If we use wetting of the soil to five feet depth as a proxy for local aquifer recharge, this suggests that aquifer recharge as a result of irrigation has been decreased in the Pratt Creek drainage.

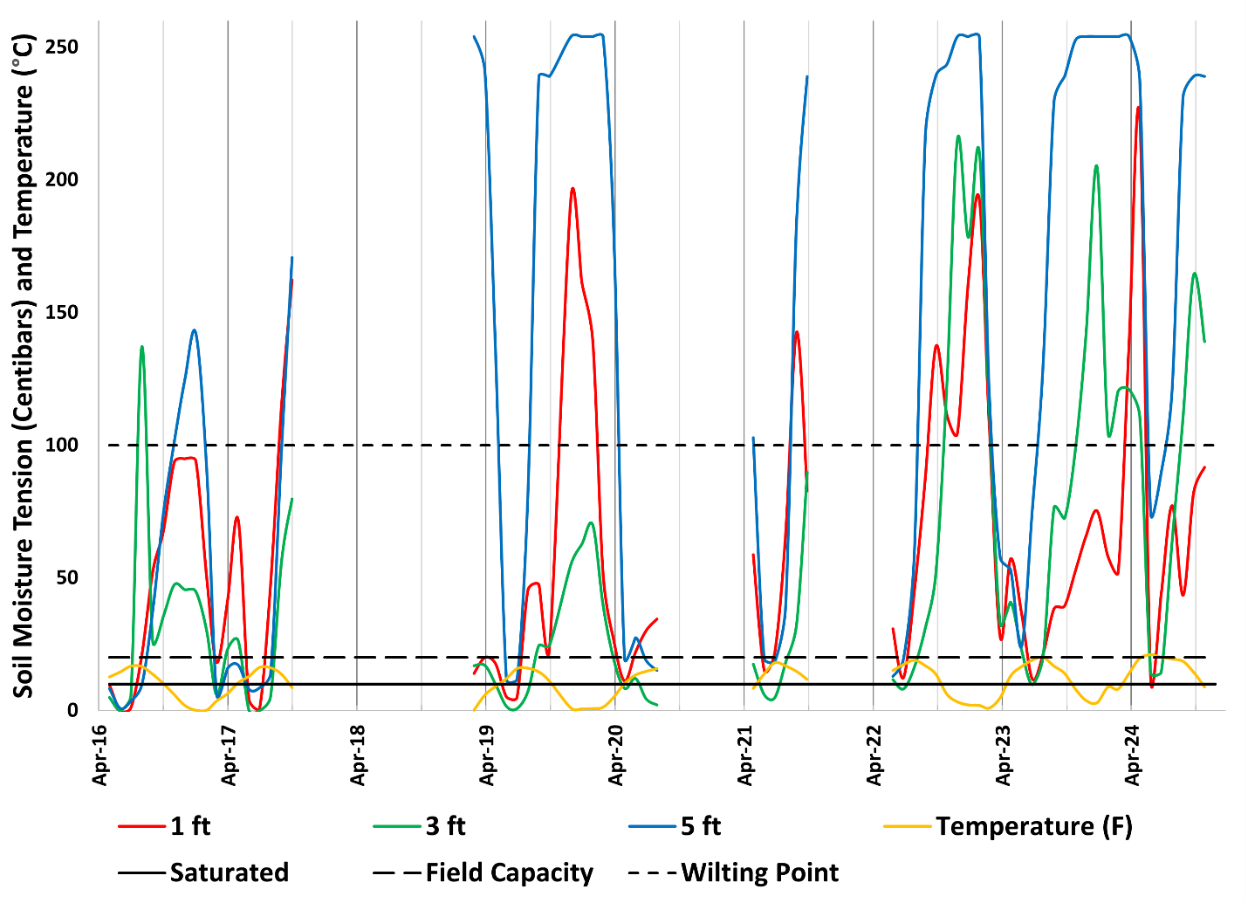


Figure 27. Pratt Creek drainage soil water tension from water year 2016 through water year 2023

Task 11 – Trends in Streamflow and Groundwater Levels

IDWR previously characterized long-term trends in streamflow and groundwater levels in the Upper Salmon Basin Groundwater and Surface Water Interactions V report (IDWR, 2022). Following review of those results, the USBWP Advisory Committee raised additional questions, prompting further analyses by IDWR.

Task 11a. Trends in Streamflow

Regarding streamflow trends, stakeholders asked the following questions:

1) What are the impacts of the 2021 drought on streamflow trend analyses? The period of record assessed for trends in the previous study (IDWR, 2022) ended in 2020, and stakeholders were curious if the results of the analysis might change with inclusion of more recent data. See "Long-term trends in streamflow" and "Streamflow drought sensitivity analysis".
2) What are the trends in natural streamflow (e.g., if no diversions were present)? See "Trends in minimally influenced streamflow".
3) Were there any trends in seasonality? See "Trends in streamflow seasonality"

Long-Term Trends in Streamflow

Streamflow trend analyses were conducted using a two-step process consisting of (1) metric-specific data screening and annual metric computation, followed by (2) application of nonparametric trend tests to the finalized annual datasets. Daily streamflow data were first restricted to the April 1 to October 31 analysis window to minimize the effects of icing and were screened to determine whether individual years met predefined completeness, seasonal coverage, and continuity criteria appropriate for each metric. Annual mean flow, maximum daily flow, and 7-day minimum flow were computed only for years with at least 90% completeness within the relevant seasonal window (April 1-October 31 for mean flow, April 1-July 15 for maximum flow, and July 16-October 31 for minimum flow). Years containing uninterrupted gaps of 14 days or more within any seasonal window were excluded to reduce the influence of nonrepresentative annual statistics.

Following completion of the data screening process (Appendix B), the resulting annual datasets were evaluated to ensure sufficient record length for trend analysis. Mann-Kendall and Sen's slope tests were applied only to metrics with at least ten years of qualifying data. Where interannual gaps exceeded five consecutive years without qualifying data, trend tests were conducted on the most recent continuous record that satisfied all screening criteria. This approach ensured that all trend analyses were based on annual metrics derived from data records of adequate length and completeness. The period of record analyzed for each gage and metric, as well as the results of the Mann-Kendall and Sen's slope tests, are reported in Table 13. For all analyses in Tasks 11a and 11b, the null hypothesis assumed no measurable trend. Results with a p-values less than or equal to 0.05 were interpreted as statistically significant evidence against the null hypothesis, values greater than 0.05 and less than or equal to 0.10 were considered marginally significant, and the null hypothesis was not rejected if p-values were greater than 0.10.

Table 13. Mann-Kendall trend test results for seasonal streamflow (April 1-October 31). Dark gray highlighted rows indicate significant trends (p≤0.05). Light gray highlighted rows indicate marginally significant trends (p≤0.10).

Gage Name	Metric	Period Analyzed	n	p-value	Sen's Slope (cfs per decade)	Median of Annual Values	% Change per Decade
Agency Creek	Min	2005-2025	*16*	*0.06*	*-1.1*	*2.4*	*-44.8*
Agency Creek	Max	2006-2024	16	0.19	-25.6	59.4	-43.1
Agency Creek	Mean	2006-2024	*14*	*0.05*	*-7.2*	*12.2*	*-58.6*
Big Eightmile Creek Lower	Min	2008-2022	12	0.24	-1.2	2.3	-52.8
Big Eightmile Creek Lower	Max	2009-2023	13	0.36	-45.9	70.1	-65.5
Big Eightmile Creek Lower	Mean	2009-2022	10	0.37	-4.6	9.7	-47
Big Eightmile Creek Upper	Min	2005-2025	18	0.36	0.6	6.3	9.3
Big Eightmile Creek Upper	Max	2006-2025	17	0.87	5.1	125	4.1
Big Eightmile Creek Upper	Mean	2006-2025	*15*	*0.09*	*-8.8*	*28.9*	*-30.4*
Big Springs Creek Lower	Min	2005-2025	16	0.44	1.1	17.6	6.1
Big Springs Creek Lower	Max	2007-2025	*18*	*0.02*	*-14.1*	*47.3*	*-29.9*
Big Springs Creek Lower	Mean	2007-2025	16	0.14	-3.4	26	-13
Big Springs Creek Upper	Min	2008-2025	18	0.13	2.1	26.2	8.1

Gage Name	Metric	Period Analyzed	n	p-value	Sen's Slope (cfs per decade)	Median of Annual Values	% Change per Decade
Big Springs Creek Upper	Max	2009-2024	*15*	*0.01*	*-27.6*	*50*	*-55.1*
Big Springs Creek Upper	Mean	2009-2024	*15*	*0.02*	*-7*	*33.7*	*-20.9*
Big Timber Creek nr Leadore	Min	2009-2025	13	0.58	-0.6	1.1	-56.1
Big Timber Creek nr Leadore	Max	2009-2025	14	0.27	-53.5	102	-52.6
Big Timber Creek nr Leadore	Mean	2009-2025	*13*	*0.10*	*-8*	*13*	*-61.8*
Big Timber Creek Upper	Min	2005-2022	17	0.17	-1.4	14.2	-10
Big Timber Creek Upper	Max	2006-2023	16	0.39	54.2	212	25.5
Big Timber Creek Upper	Mean	2006-2022	16	0.30	-9.3	49.6	-18.8
Bohannon Creek Lower	Min	2008-2025	17	0.28	0.4	1.3	31.3
Bohannon Creek Lower	Max	2009-2025	*16*	*0.06*	*-20.5*	*44.6*	*-45.9*
Bohannon Creek Lower	Mean	2009-2025	*15*	*0.09*	*-4.1*	*7.0*	*-59.4*
Bruno Creek nr Clayton	Min	1971-2025	*55*	*0.05*	*-0.02*	*0.1*	*-14.8*
Bruno Creek nr Clayton	Max	1972-2025	*54*	*0.02*	*-1.3*	*5.8*	*-21.9*
Bruno Creek nr Clayton	Mean	1971-2025	*55*	*<0.01*	*-0.3*	*1.0*	*-28.7*
Canyon Creek	Min	2008-2025	17	0.11	0.5	0.8	57.3
Canyon Creek	Max	2009-2025	15	0.11	-6.9	10.7	-64.5
Canyon Creek	Mean	2009-2025	15	0.23	-1.1	4.6	-23.8
Carmen Creek Lower	Min	2005-2025	19	0.46	0.2	0.6	24.6
Carmen Creek Lower	Max	2006-2025	18	0.94	2.3	179	1.3
Carmen Creek Lower	Mean	2006-2025	18	0.32	-5.3	24.7	-21.4
Carmen Creek Upper	Min	2005-2018	12	0.37	-2.2	3.6	-62.2
Carmen Creek Upper	Max	2006-2018	10	0.86	-32.2	211	-15.3
Carmen Creek Upper	Mean	2006-2018	11	0.88	-1.7	37.6	-4.6
Challis Creek Lower	Min	2005-2019	15	0.62	-0.1	0.5	-21.3
Challis Creek Lower	Max	2006-2019	13	0.95	1.3	185	0.7
Challis Creek Lower	Mean	2006-2019	13	0.43	8.5	35.8	23.7
Challis Creek Upper	Min	2005-2018	12	0.37	1.9	14.9	12.4
Challis Creek Upper	Max	2006-2018	12	0.45	74.7	198	37.7
Challis Creek Upper	Mean	2006-2018	10	0.37	11.3	55.9	20.1
East Fork Salmon River	Min	2004-2017	*14*	*0.10*	*27.1*	*89.4*	*30.3*
East Fork Salmon River	Max	2005-2018	14	0.58	418	1530	27.3
East Fork Salmon River	Mean	2004-2017	14	0.44	42.8	327	13.1
Eighteenmile Creek	Min	2006-2023	13	0.22	1.1	2.5	43.6
Eighteenmile Creek	Max	2007-2023	11	0.35	17.6	28	63
Eighteenmile Creek	Mean	2006-2013	9	NA	NA	14.1	NA
Fourth of July Creek	Min	2004-2012	13	0.30	-2.5	2.6	-94.9
Fourth of July Creek	Max	2006-2025	*15*	*0.08*	*-70*	*163*	*-42.9*
Fourth of July Creek	Mean	2018-2025	10	0.15	-14.1	31.6	-44.5
Hawley Creek Upper	Min	2008-2022	11	0.64	3.5	12.8	27.2
Hawley Creek Upper	Max	2009-2022	*12*	*0.09*	*-28.1*	*31.5*	*-89.1*

Gage Name	Metric	Period Analyzed	n	p-value	Sen's Slope (cfs per decade)	Median of Annual Values	% Change per Decade
Hawley Creek Upper	Mean	2009-2022	9	NA	NA	20.2	NA
Hayden Creek	Min	2008-2025	*18*	*0.06*	*-3.9*	*17.1*	*-22.6*
Hayden Creek	Max	2009-2025	16	0.14	-215	552	-38.9
Hayden Creek	Mean	2008-2025	*17*	*0.02*	*-37.1*	*109*	*-34*
Iron Creek	Min	2006-2025	13	0.95	-0.7	5.2	-12.5
Iron Creek	Max	2007-2025	17	0.65	12.2	153	8.0
Iron Creek	Mean	2007-2025	15	0.84	-1.1	28.7	-3.8
Kenney Creek	Min	2004-2025	*16*	*0.03*	*1.3*	*1.3*	*107*
Kenney Creek	Max	2005-2025	17	1.00	-1.0	32.7	-3.0
Kenney Creek	Mean	2005-2025	16	0.44	1.1	9.2	12.4
Lee Creek	Min	2009-2025	13	0.58	-0.4	1.3	-34
Lee Creek	Max	2010-2025	*14*	*0.06*	*-17.4*	*14.7*	*-118.4*
Lee Creek	Mean	2010-2025	*12*	*0.01*	*-4.5*	*3.8*	*-120*
Lemhi River at Big Springs	Min	2005-2025	*21*	*0.05*	*-7.2*	*37.8*	*-19*
Lemhi River at Big Springs	Max	2006-2025	19	0.18	-46.8	170	-27.5
Lemhi River at Big Springs	Mean	2006-2025	19	0.33	-13.8	73.3	-18.8
Lemhi River at Cottom Ln	Min	2005-2025	20	0.67	-3.2	70.5	-4.5
Lemhi River at Cottom Ln	Max	2006-2025	19	0.23	-50.2	272	-18.4
Lemhi River at Cottom Ln	Mean	2006-2025	19	0.58	-7.9	116	-6.8
Lemhi River at L1	Min	2011-2023	11	0.44	-15.7	60.1	-26.2
Lemhi River at L1	Max	2012-2024	12	0.54	225	911	24.7
Lemhi River at L1	Mean	2012-2023	10	0.72	35.6	269	13.3
Lemhi River at L63	Min	2008-2019	12	0.54	-2.6	6.7	-39
Lemhi River at L63	Max	2009-2019	11	0.64	-10.3	72.2	-14.2
Lemhi River at L63	Mean	2009-2019	11	1.00	0.9	18.6	4.9
Lemhi River bl L5 Diversion	Min	1993-2025	33	0.79	0.2	25	0.7
Lemhi River bl L5 Diversion	Max	1993-2025	32	0.19	-176	871	-20.2
Lemhi River bl L5 Diversion	Mean	1993-2025	32	0.39	-16.1	207	-7.8
Lemhi River nr McFarland	Min	2012-2025	10	0.37	22.5	50.2	44.8
Lemhi River nr McFarland	Max	2012-2025	10	1.00	NA	282	0.0
Lemhi River nr McFarland	Mean	2012-2025	10	0.72	6.3	105	6.0
Lemhi River nr Lemhi	Min	1968-2025	66	0.13	-3.6	96.4	-3.7
Lemhi River nr Lemhi	Max	1956-2025	66	0.13	-40.9	736	-5.6
Lemhi River nr Lemhi	Mean	1968-2025	*65*	*0.02*	*-15.1*	*237*	*-6.3*
Little Springs Creek Lower	Min	2009-2024	10	0.47	3.7	6.6	56.6
Little Springs Creek Lower	Max	2009-2024	14	0.66	-2.3	18.7	-12.5
Little Springs Creek Lower	Mean	2009-2024	10	0.59	3.5	9.9	35.6
Napias Creek bl Arnett Creek	Min	1999-2025	27	0.74	-0.1	8.6	-1.0
Napias Creek bl Arnett Creek	Max	1999-2025	27	0.77	-8.0	202	-4.0
Napias Creek bl Arnett Creek	Mean	1999-2025	27	0.45	2.5	37.6	6.5

Gage Name	**Metric**	**Period Analyzed**	**n**	**p-value**	**Sen's Slope (cfs per decade)**	**Median of Annual Values**	**% Change per Decade**
Paasasikwana Naokwaide bl Bruno Ck	Min	1976-2025	50	0.68	-0.1	8.6	-1.4
Paasasikwana Naokwaide bl Bruno Ck	Max	1976-2025	50	0.93	1.0	222	0.5
Paasasikwana Naokwaide bl Bruno Ck	Mean	1976-2025	50	0.7	-0.8	41	-2.0
Pahsimeroi River at Ellis	Min	1985-2025	41	0.43	1.7	112	1.5
Pahsimeroi River at Ellis	Max	1985-2025	41	0.16	-13.7	308	-4.5
Pahsimeroi River at Ellis	Mean	1985-2025	41	0.73	-1.9	176	-1.1
Pahsimeroi River at Furey Ln	Min	2010-2019	6	NA	NA	5.8	NA
Pahsimeroi River at Furey Ln	Max	2008-2019	10	0.72	42	116	36.1
Pahsimeroi River at Furey Ln	Mean	2010-2019	6	NA	NA	36.8	NA
Pahsimeroi River at P9	Min	2005-2025	19	0.94	0.9	7.5	11.4
Pahsimeroi River at P9	Max	2006-2025	18	0.23	-13.4	89.5	-14.9
Pahsimeroi River at P9	Mean	2006-2025	17	0.11	-7.1	27.3	-26.1
Panther Creek at Cobalt	Min	2012-2025	14	0.38	-2.4	30.2	-7.9
Panther Creek at Cobalt	Max	2012-2025	14	0.51	-110	635	-17.3
Panther Creek at Cobalt	Mean	2012-2025	14	0.44	-24.1	124	-19.4
Patterson Big Springs Upper	Min	2008-2025	*15*	*<0.01*	*-15.3*	*17.7*	*-86.3*
Patterson Big Springs Upper	Max	2009-2025	16	0.30	-13.9	61.1	-22.7
Patterson Big Springs Upper	Mean	2009-2025	*14*	*<0.01*	*-20*	*32.3*	*-62*
Pole Creek	Min	2005-2025	*15*	*0.01*	*6.2*	*7.5*	*82.5*
Pole Creek	Max	2006-2016	13	0.30	-18.6	61.5	-30.2
Pole Creek	Mean	2006-2025	14	0.91	-2.0	20.7	-9.5
Salmon River at Salmon	Min	1913-2025	*109*	*0.05*	*-16.9*	*910*	*-1.9*
Salmon River at Salmon	Max	1913-2025	110	0.83	-17.6	8990	-0.2
Salmon River at Salmon	Mean	1913-2025	109	0.57	-15	2430	-0.6
Salmon River bl Yankee Fork	Min	2000-2025	*26*	*0.02*	*30.9*	*392*	*7.9*
Salmon River bl Yankee Fork	Max	2001-2025	25	0.87	143	4690	3.1
Salmon River bl Yankee Fork	Mean	2001-2025	25	0.36	89	1270	7.0
Salmon River nr Shoup	Min	2003-2025	23	0.49	56.8	977	5.8
Salmon River nr Shoup	Max	2003-2025	23	0.83	-429	13000	-3.3
Salmon River nr Shoup	Mean	2003-2025	23	0.87	70.2	3270	2.1
Texas Creek	Min	2008-2021	11	1.00	1.1	5.4	20.1
Texas Creek	Max	2009-2022	8	NA	NA	61.4	NA
Texas Creek	Mean	2009-2019	6	NA	NA	22.8	NA
Thompson Creek nr Clayton	Min	1973-2025	*53*	*<0.01*	*-0.3*	*3.5*	*-9.0*
Thompson Creek nr Clayton	Max	1973-2025	53	0.33	-6.2	117	-5.3
Thompson Creek nr Clayton	Mean	1973-2025	53	0.29	-1.3	21.2	-6.2
Valley Creek at Stanley	Min	1993-2025	33	0.35	2.8	74	3.8
Valley Creek at Stanley	Max	1993-2025	33	0.60	-29.8	943	-3.2
Valley Creek at Stanley	Mean	1993-2025	33	0.57	-6.7	261	-2.6
Yankee Fork Salmon River nr Clayton	Min	2012-2025	13	0.20	-6.8	56.3	-12

Gage Name	Metric	Period Analyzed	n	p-value	Sen's Slope (cfs per decade)	Median of Annual Values	% Change per Decade
Yankee Fork Salmon River nr Clayton	Max	2012-2025	13	0.16	-450	1460	-30.8
Yankee Fork Salmon River nr Clayton	Mean	2012-2025	13	0.36	-67	334	-20.1

Note that several stream gages included in this analysis have relatively short periods of record. Gages with only one or two decades of data are susceptible to the influence of recent drought or wet years, which can dominate the dataset and create the appearance of strong trends. As a result, some apparent trends may reflect short-term hydrologic variability rather than long-term trends in flow regime. IDWR encourages the reader to consider the period of record when interpreting the results.

Lemhi Basin:

Statistically significant (p<0.05) (dark shading) or marginally statistically significant (p<0.10) (light shading) downward trends in April-October mean streamflow was observed at seven tributary gages and one gage on the mainstem Lemhi River (Table 13): Agency Creek (-7.2 cfs/decade), Big Springs Creek Upper (-7.0 cfs/decade), Hayden Creek (-37.1 cfs/decade), Lee Creek (-4.5 cfs/decade), Big Eightmile Creek Upper (-8.8 cfs/decade), Big Timber Creek nr Leadore (-8.0 cfs/decade), Bohannon Creek Lower (-4.1 cfs/decade), and Lemhi River nr Lemhi (-15.1 cfs/decade) (Figure 28).

Three gages expressed a significant or marginally significant downward trend in seasonal mean streamflow without observed trends in maximum or minimum flows: Lemhi River nr Lemhi (n=65, p=0.02), Big Eightmile Creek Upper (n=15, p=0.09), and Big Timber Creek nr Leadore (n=13, p=0.10). These results may indicate changes in the seasonal distribution of flow, such as shorter periods of runoff or extended periods of baseflow. However, because the tributary gages have shorter periods of record, recent drought conditions may be influencing results. Given that several tributaries in the headwaters of the Lemhi River are exhibiting downward trends in mean seasonal streamflow, it is unsurprising that the Lemhi River nr Lemhi gage, which is situated downgradient of these tributaries, is affected by flow regime changes higher in the basin.

Five gages on four tributaries exhibit statistically significant or marginally statistically significant declines in seasonal maximum streamflow (Table 13): Big Springs Creek Upper (n=15, p=0.01, -27.6 cfs/decade), Big Springs Creek lower (n=18, p=0.02, -14.1 cfs/decade), Hawley Creek (n=12, p=0.09, -28.6 cfs/decade), Lee Creek (n=14, p=0.06, -17.4 cfs/decade), and Bohannon Creek Lower (n=16, p=0.06, -20.5 cfs/decade) (Figure 29). Typically, declines in maximum streamflow may suggest a reduction in peak runoff, or a shift towards increased retention and prolonged discharge during flood events. However, given the short periods of record, the observed trends may also reflect the influence of recent drought conditions rather than long-term hydrologic change. To fully evaluate long-term trends, additional years of data are needed.

Two tributary gages and one gage on the Lemhi River show a statistically significant or marginally statistically significant downward trend in seasonal minimum streamflow: Agency Creek (n=16, p=0.06, -1.0 cfs/decade), Hayden Creek (n=18, p=0.06, -3.9 cfs/decade), and Lemhi at Big Springs Creek (n=21, p=0.05, -7.2 cfs/decade) (Figure 30). Kenney Creek (n=16, p=0.03, +1.3 cfs/decade), is the only gage with a statistically significant increase in minimum streamflow. A likely contributing factor is that in 2019, the largest water user on Kenney Creek entered a conservation easement, which helped to increase IWTP's target flow from 0.14 cfs to 4.0 cfs.

Declines in seasonal mean streamflow indicate a reduced water supply during the irrigation season, which increases the likelihood of water right curtailment, due in part to the minimum streamflow provision of 35 cfs at the Lemhi River below L5 diversion gage. Reductions in mean and minimum flows during the irrigation season may also decrease the volume of water conveyed through unlined canals and ditches, which provide supplemental aquifer recharge via seepage (Donato, 1998). Lower transport capacity in these systems could diminish drought resilience and reduce the buffering capacity of the local aquifer.

Alterations in flow regimes may affect ESA listed Snake River Steelhead and Chinook Salmon. Decreases in minimum flows reduce available rearing habitat and limit fish passage to historic spawning reaches. Reduced summer flows can exacerbate thermal stress by shrinking the extent of cold water refugia. If peak flows are declining, geomorphic processes that help maintain channel complexity, such as floodplain connectivity, wood and gravel recruitment, and scour, may also be diminished.

Pahsimeroi Basin:

In the Pahsimeroi Basin, Patterson Big Springs Creek Upper observed a statistically significant downward trend in seasonal mean (n=14, p<0.01, -20.0 cfs/decade) (Figure 28) and minimum streamflow (n=15, p<0.01, -15.3 cfs/decade) (Figure 30). No detectable trends were observed at Pahsimeroi at P9 (upstream of the Patterson Big Springs Creek confluence) or Pahsimeroi at Ellis (located immediately upstream of the confluence to the Salmon River). This suggests that gains in streamflow from groundwater or tributaries between the Pahsimeroi at P9 and Ellis gages may be offsetting the losses occurring at Patterson Big Springs Creek. Given the short period of record, continued monitoring will help clarify whether these gains persist or broader basin scale declines emerge.

Upper Salmon Basin:

The only statistically significant trend in seasonal mean streamflow outside of the Lemhi and Pahsimeroi basins was detected at Bruno Creek nr Clayton (n=55, p<0.01, -0.3 cfs/decade) (Table 11). The presence of a trend at a single gage suggests that basin-wide precipitation patterns have remained relatively stable, or that water management practices have contributed to increased in-stream flow volumes.

Two gages exhibited statistically significant or marginally statistically significant declines in seasonal maximum streamflow: Bruno Creek nr Clayton (n=54, p=0.02, -1.3 cfs/decade) and Fourth of July Creek (n=15, p=0.08, -70.00 cfs/decade) (Figure 29). Declines in seasonal maximum streamflow may indicate reduced peak runoff or shifts in snowpack dynamics in high catchments. However, given the short period of record at Fourth of July Creek, these trends may also reflect the influence of recent drought years rather than long-term hydrologic shifts. With the limited number of gages in the Upper Salmon Basin exhibiting declines in seasonal maximum streamflow, observed reductions may represent localized conditions rather than basin-wide patterns. Additional years of monitoring will be needed to fully evaluate long-term trends.

Four gages display statistically significant or marginally statistically significant trends in seasonal minimum streamflow: Pole Creek (n=15, p<0.01, +6.2 cfs/decade), Salmon River bl Yankee Fork (n=26, p=0.02, +30.9 cfs/decade), East Fork Salmon River (n=14, p=0.10, +27.1 cfs/decade) and Salmon River at Salmon (n=109, p=0.05, -16.9 cfs/decade) (Figure 30). Increases in minimum flows at Pole Creek may reflect recent water right acquisitions or restoration actions that enhance baseflow conditions. The increased minimum flows in the East Fork Salmon River may serve to bolster in-stream habitat for salmonids and decrease curtailment for irrigators during periods of low-flow. Despite the observed decline at the Salmon River at Salmon gage, the long period of record and relatively modest percent-change per decade suggest generally stable minimum flow conditions in the mainstem of the Salmon River. Two additional gages: Bruno Creek nr Clayton (n=55, p=0.05) -0.02 cfs/decade) and Thompson Creek nr Clayton (n=53, p<0.01) -0.3 cfs/decade) show statistically significant declines in seasonal minimum streamflow. However, the magnitude of change is negligible (-0.02 cfs/decade and -0.3 cfs/decade) and likely within measurement error.

Across the entire Upper Salmon Basin, trends in seasonal streamflow vary by basin and metric. The Lemhi Basin shows the most widespread changes: multiple tributaries exhibit statistically significant or marginally significant declines in streamflow metrics, suggesting shifts in seasonal flow distribution may be influenced by recent drought years and shorter gage records. Significant declines in streamflow within the Pahsimeroi Basin was limited to the Patterson Big Springs Creek Upper gage. The absence of detectable trends at nearby gages points to these changes being localized rather than reflective of basin-wide conditions.

The broader Upper Salmon Basin has experienced more dynamic trends: only one gage exhibited a decline in mean seasonal streamflow, and two gages display declines in maximum flows, suggesting that reductions in peak runoff are not widespread. Minimum flow trends in the Upper Salmon Basin are mixed, with both increases and decreases occurring at individual gages.

Collectively, these findings highlight the need to distinguish short-term anomalies from emerging long-term trends. Strengthening the dataset with additional years of monitoring may help refine these interpretations and support more resilient planning in the Upper Salmon Basin.

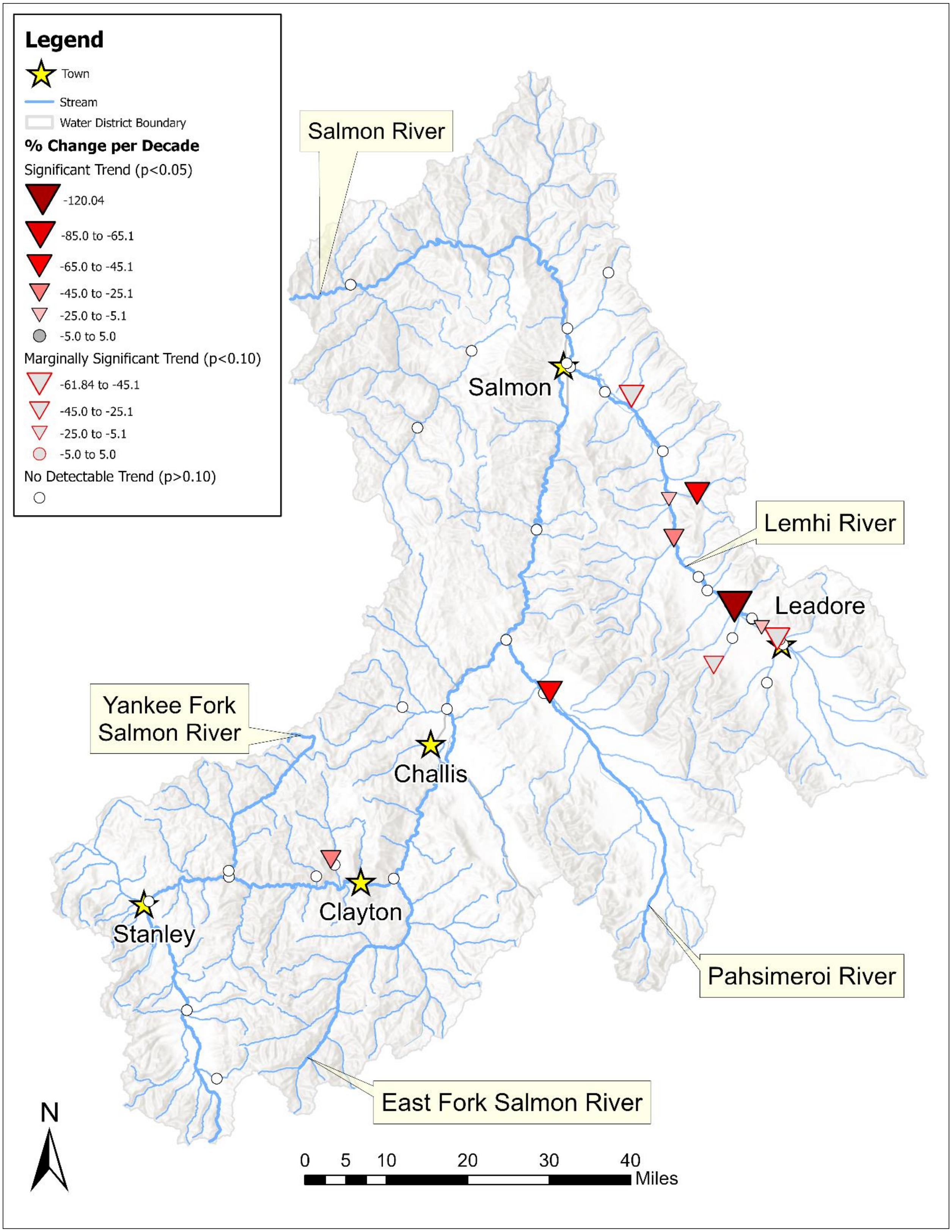


Figure 28. Percent change in decadal April-October mean streamflow trends in the Upper Salmon Basin

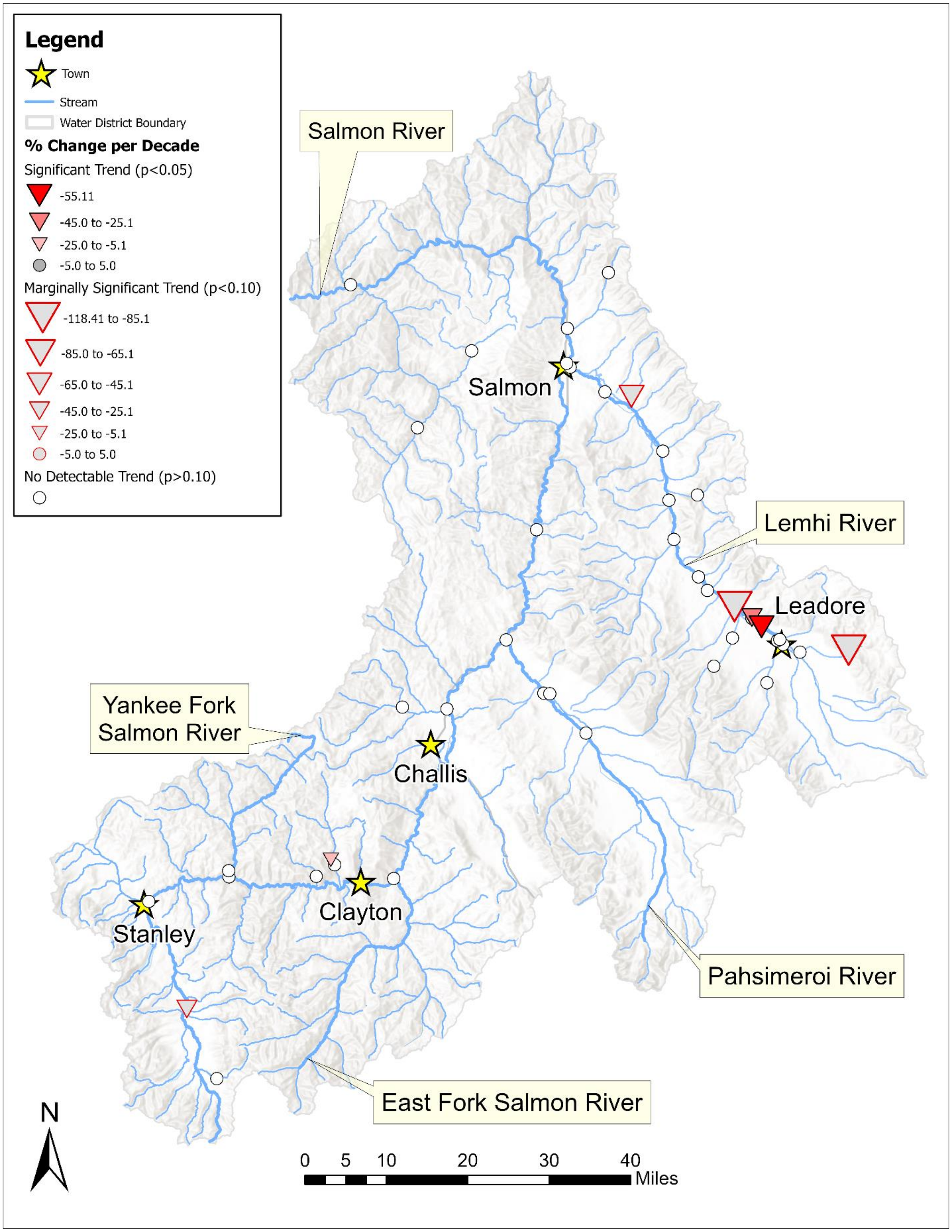


Figure 29. Percent change in decadal April-October maximum streamflow trends in the Upper Salmon Basin

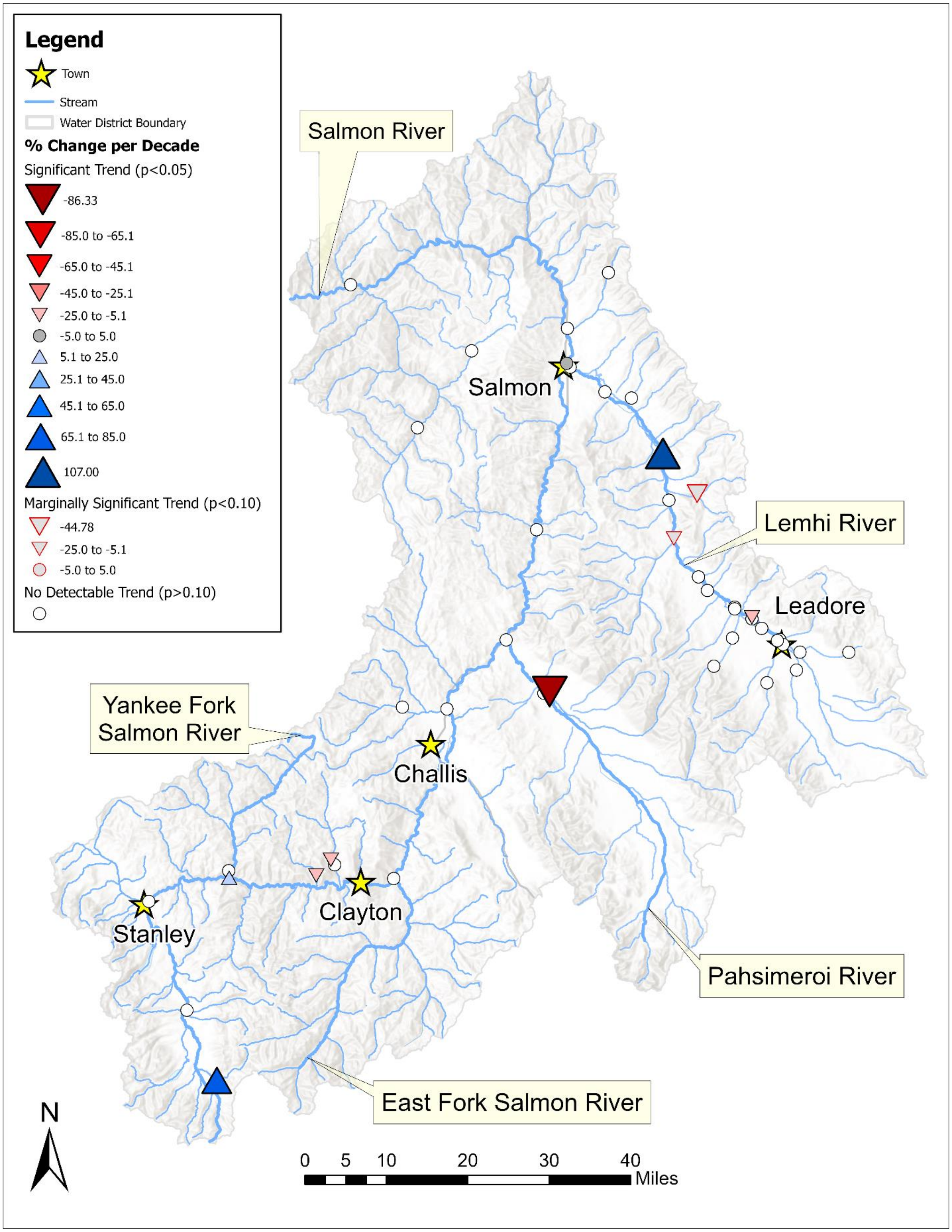


Figure 30. Percent change in decadal April through October minimum streamflow trends in the Upper Salmon Basin

Streamflow drought sensitivity analysis

On July 2, 2021, Lemhi County declared a drought emergency (Idaho Office of the Governor, 2021). At that time, the year-to-date precipitation levels through June 1, 2021, for the Salmon River above Salmon Gage were approximately 72% of average. In addition, streamflow for the Salmon River at Salmon and Lemhi River near Lemhi was forecasted to be only 38% of normal from June through September.

The Palmer Drought Severity Index (PDSI) is a drought indicator that uses monthly temperature and precipitation data to estimate cumulative moisture deficits or surpluses. PDSI values greater than two indicate moist conditions and values less than negative two indicate drought conditions. The greater the magnitude of the index, the more severe the drought/moistness is. Because the index incorporates climatic memory, it captures the duration and magnitude of prolonged drought conditions rather than short-term anomalies, thus, making it useful to identify long-term drought trends.

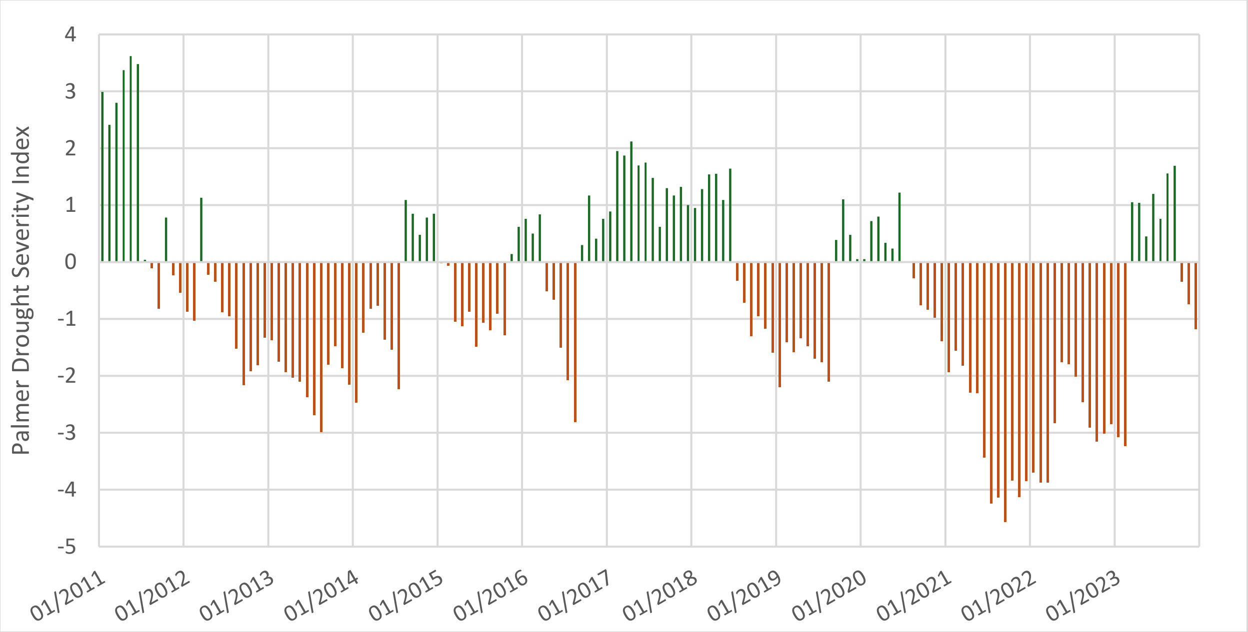


Figure 31. Monthly PDSI values for Lemhi County, ID. 2011-2023

In April of 2021, Lemhi County entered a severe drought (-3.9 to -3.0) and then an extreme drought (less than -4.0) in July, which lasted through November. In 2022, the county fluctuated between severe and moderate (-2.9 to -2.0) drought. By 2023, the region transitioned back to near normal (-1.9 to +1.9) conditions (Figure 31), presenting an opportunity for recovery of streamflow and groundwater levels back towards historic norms. Additionally, the National Integrated Drought Information System (Drought.gov) provides spatiotemporal drought information at finer-scale, and corroborates these findings. The remainder of this section explores the degree to which streamflow was impacted by the 2021 drought, as well as how quickly flows recovered after 2021.

Table 14 compares the basin-averaged percent change per stream gage in annual 7-day minimum streamflow, maximum streamflow, and mean streamflow when compared to the median values from the 2011 to 2020 period. The period of record for all gages was limited to April 1 through October 31 to minimize the impacts of icing and data gaps on the analysis. Percent change for each metric was computed by averaging the changes in flow for each individual stream gage within a basin, rather than calculating the total volume of flow at all gages.

The Upper Salmon Basin (Table 14) includes all stream gages within the entire Upper Salmon Basin, including the Lemhi Basin (Figure 1). The Lemhi Basin only includes gages within the Lemhi Basin. The Upper Lemhi Subbasin and Lower Lemhi Subbasin divide the Lemhi Basin in two, with the dividing line just upstream of the Lemhi River nr Lemhi Gage. This arbitrary boundary matches that of the Donato (1998) report and is used to illustrate the hydrogeologic differences between the upper and lower basin.

Table 14. Percent change in annual streamflow relative to the 2011-2020 median

Basin	Metric	2021	2022	2023
Upper Salmon Basin	Min	-28.4%	-16.3%	-4.6%
Upper Salmon Basin	Max	-49.8%	29.4%	5.2%
Upper Salmon Basin	Mean	-47.5%	-18.2%	5.6%
Lemhi Basin	Min	-21.2%	-26.8%	-4.0%
Lemhi Basin	Max	-40.5%	32.8%	-0.6%
Lemhi Basin	Mean	-37.2%	-23.1%	5.6%
Upper Lemhi Subbasin	Min	-19.1%	-29.1%	-4.0%
Upper Lemhi Subbasin	Max	-37.4%	25.1%	-1.5%
Upper Lemhi Subbasin	Mean	-34.2%	-23.1%	-2.3%
Lower Lemhi Subbasin	Min	-22.5%	-13.7%	-7.4%
Lower Lemhi Subbasin	Max	-49.8%	62.7%	5.2%
Lower Lemhi Subbasin	Mean	-54.2%	-26.3%	13.9%

In the Upper Lemhi Subbasin, all three streamflow metrics show persistent deficits following the onset of the 2021 drought. In 2021, streamflows were significantly reduced with values ranging from 19.1% to 37.4% below normal, and 2022 did not see much improvement. By 2023, conditions improved but did not fully rebound: minimum flows remained at -4% and the mean flow remained 2.3% below the baseline median. These results indicate that the Upper Lemhi Subbasin was slower to recover from the 2021 drought and remained hydrologically stressed even as conditions improved elsewhere.

The Lower Lemhi Subbasin displays a wider range of variability and a stronger rebound following the 2021 drought. Minimum flows remained negative across all three years, but maximum flows recovered to 5.2% above baseline in 2023. Mean conditions similarly shifted from a large deficit in 2021 to a surplus of 13.9% in 2023. This suggests that lower subbasin hydrology responded more quickly to improved water availability, potentially due to localized recharge, groundwater contributions, or changes in water management practices.

At the Lemhi Basin scale the pattern reflects the interplay between the slower to recover Upper Lemhi Subbasin and the more responsive Lower Lemhi Subbasin. Minimum and mean streamflows remain negative in both 2021 and 2022. By 2023, mean streamflow rose to 5.6% above average.

In the Upper Salmon Basin, deficits were most pronounced in 2021 with metrics falling between -28.4% and -49.8% below baseline medians. Conditions improved substantially in 2022, and by 2023 both maximum and mean values were slightly above average. The trajectory indicates a strong basin-wide recovery, though initial drought impacts were severe.

Trends in minimally influenced streamflow

Streamflow trend analyses were conducted for the December through March period at stream gages with adequate winter records. This period represents conditions of minimal human influence on streamflow, as it occurs outside of the irrigation season. Screening criteria for gage and year inclusion generally mirrored those applied to the April through October Mann-Kendall analyses. Annual seasonal streamflow metrics, including 7-day minimum flow, maximum daily flow, and mean flow, were first computed. Trend analyses were performed on gages with at least ten years of screened annual values. When data gaps exceeding five years occurred, trend analyses were restricted to the most recent continuous segment of record, rather than aggregating discontinuous periods. Results of the December through March trend analyses are summarized in Table 15.

Table 15. Mann-Kendall trend test results for winter (December 1-March 31) streamflow. Dark gray highlighted rows indicate significant trends (p≤0.05). Light gray highlighted rows indicate marginally significant trends (p≤0.10).

Gage Name	Metric	Period Analyzed	n	p-value	Sen's Slope (cfs per decade)	Median of Winter Values	% Change per Decade
Lemhi River at Big Springs	Min	2006-2025	*18*	*0.04*	*-13.2*	*63.2*	*-21.0*
Lemhi River at Big Springs	Max	2006-2025	18	0.60	-15.0	161	-9.3
Lemhi River at Big Springs	Mean	2006-2025	18	0.50	-6.7	98.4	-6.8
Lemhi River at Cottom Ln	Min	2006-2024	15	0.69	-4.5	141	-3.2
Lemhi River at Cottom Ln	Max	2006-2024	15	0.92	4.2	239	1.8
Lemhi River at Cottom Ln	Mean	2006-2024	15	0.69	4.6	169	2.7
Lemhi River bl L5 Diversion	Min	1993-2024	31	0.57	-5.9	193	-3.1
Lemhi River bl L5 Diversion	Max	1993-2024	31	0.20	-55.0	403	-13.7
Lemhi River bl L5 Diversion	Mean	1993-2024	31	0.95	-1.2	258	-0.5
Lemhi River nr Lemhi	Min	1956-2024	*65*	*0.05*	*-3.9*	*172*	*-2.3*
Lemhi River nr Lemhi	Max	1956-2024	65	0.17	-9.2	327	-2.8
Lemhi River nr Lemhi	Mean	1956-2024	65	0.24	-3.0	232	-1.3
Pahsimeroi River at Ellis	Min	1985-2025	41	0.50	-2.9	229	-1.3
Pahsimeroi River at Ellis	Max	1985-2025	*41*	*0.03*	*-18.5*	*307*	*-6.0*
Pahsimeroi River at Ellis	Mean	1985-2025	41	0.14	-10.3	261	-3.9
Panther Creek at Cobalt	Min	2012-2024	13	0.85	-1.2	22.8	-5.2
Panther Creek at Cobalt	Max	2012-2024	13	0.36	-21.1	56.3	-37.5
Panther Creek at Cobalt	Mean	2012-2024	13	0.36	-6.4	29.6	-21.5
Salmon River nr Shoup	Min	2003-2024	*22*	*0.06*	*132.5*	*1240*	*10.7*
Salmon River nr Shoup	Max	2003-2024	22	0.98	15.4	2130	0.7
Salmon River nr Shoup	Mean	2003-2024	*22*	*0.10*	*153.2*	*1570*	*9.7*

Gage Name	Metric	Period Analyzed	n	p-value	Sen's Slope (cfs per decade)	Median of Winter Values	% Change per Decade
Salmon River bl Yankee Fork	Min	2001-2025	*25*	*<0.01*	*33.8*	*361*	*9.4*
Salmon River bl Yankee Fork	Max	2001-2025	25	0.5	38.2	609	6.3
Salmon River bl Yankee Fork	Mean	2001-2025	*25*	*0.02*	*32.1*	*419*	*7.7*
Salmon River at Salmon	Min	1913-2025	*110*	*0.05*	*8.8*	*881*	*1.0*
Salmon River at Salmon	Max	1913-2025	110	0.57	4.8	1440	0.3
Salmon River at Salmon	Mean	1913-2025	*110*	*0.10*	*8.6*	*1120*	*0.8*
Valley Creek at Stanley	Min	1993-2025	*33*	*0.09*	*4.0*	*71.4*	*5.6*
Valley Creek at Stanley	Max	1993-2025	33	0.96	-1.2	148	-0.8
Valley Creek at Stanley	Mean	1993-2025	33	0.36	2.8	87.1	3.2
Yankee Fork Salmon River nr Clayton	Min	2012-2025	13	0.50	1.2	43.7	2.6
Yankee Fork Salmon River nr Clayton	Max	2012-2025	13	0.58	-30.8	163	-18.9
Yankee Fork Salmon River nr Clayton	Mean	2012-2025	13	0.95	-1.4	57	-2.5

Lemhi Basin:

Two gages on the mainstem of the Lemhi River show statistically significant declining trends in winter low flow conditions: Lemhi River at Big Springs (n=18, p=0.04, -13.2 cfs per decade) and Lemhi nr Lemhi (n=65, p=0.05, -3.9 cfs per decade) (Table 15). These downward trends at both the headwater and mid-basin mainstem gages suggest that winter low-flow reductions may be occurring across broader portions of the Lemhi basin. However, given that this analysis was only conducted on gages that experience minimal icing, it is hard to pinpoint where these losses may be occurring, if at all. Declining December-March minimum flows may reflect reduced groundwater contributions in gaining portions of the Lemhi River, increased losses in losing reaches of the Lemhi River, shifts in winter precipitation or temperature patterns, or changes in snowmelt dynamics.

When analyzing April-October streamflow trends on minimally influenced gages, two gages in the Lemhi Basin are located far enough upstream as to not be affected by irrigation diversions, making them suitable indicators to detect climatic changes in the basin: Big Eightmile Creek upper and Hawley Creek upper, each expressing marginally statistically significant trends in different streamflow metrics (Table 13). Big Eightmile Creek Upper shows a marginally significant downward trend in mean April-October streamflow (n=15, p=0.09, -8.76 cfs per decade). This decline suggests a reduction in overall seasonal surface water availability during the period of record. Because this gage is located higher in the basin and is unaffected by diversions, the observed decline in seasonal mean streamflow likely reflects changes in snowpack accumulation or a shift in snowmelt timing. Hawley Creek Upper exhibits a marginally significant downward trend in maximum April-October streamflow (n=12, p=0.09, -28.06 cfs per decade). This decline in seasonal peak flow suggests that high flow events are either becoming less frequent, less intense, or shifting earlier in the year. The absence of a corresponding trend in minimum or mean flows further suggests that the most pronounced hydrologic changes may be occurring during runoff rather than across the entire season. However, given the short periods of record at these gages, the observed marginally significant trends may also reflect the influence of recent drought conditions rather than long-term hydrologic change. To fully evaluate long-term trends, additional years of data are needed.

Pahsimeroi Basin:

The Pahsimeroi River at Ellis shows a statistically significant decline in maximum winter streamflow (n=41, p=0.03, -18.5 cfs per decade) (Table 15). This reduction in winter maximum flow may indicate a shift towards later runoff events outside of the December through March record, muted early season runoff, fewer flooding events during the period of record, or shifts in precipitation patterns.

Upper Salmon Basin:

Three gages on the Salmon River show statistically significant or marginally significant increases in mean winter streamflow: Salmon River below Yankee Fork (n=25, p=0.02, +32.1 cfs per decade), Salmon River nr Shoup (n=22, p=0.10, +153.2 cfs per decade), and Salmon River at Salmon (n=110, p=0.1, +8.8 cfs per decade) (Table 15).

Minimum winter flow conditions show similar patterns. Three gages on the Salmon River exhibit increases in minimum winter flows: Salmon River below Yankee Fork (n=25, p<0.01, +33.8), Salmon River at Salmon (n=110, p=0.05, +8.8), and Salmon River nr Shoup (n=22, p=0.06, +132.5). These minimum streamflow patterns suggest either increased snowmelt or increased contributions from groundwater to surface water is occurring from December-March in the Upper Salmon Basin. The long-term period of record at the Salmon River at Salmon gage shows a significant trend increase in minimum winter flows, however the magnitude is small (1% per decade). Despite the decreases in minimum flow conditions in the Lemhi basin, the mainstem of the Salmon River near Salmon maintains relatively consistent winter baseflow conditions.

The statistically significant upward trend in wintertime streamflow metrics reinforce the pattern of increased snowmelt or meteorological shifts occurring on the Upper Salmon Basin. Collectively, the Salmon River shows a tendency toward increasing winter baseflow and mean streamflow conditions while the Lemhi and Pahsimeroi basins remain more variable.

Trends in streamflow seasonality

To evaluate potential changes in streamflow seasonality, timing metrics were computed for each qualifying gage using daily mean discharge during the April 1 through October 31 period. For each year, cumulative discharge was calculated for this period, and the calendar day on which 25% (p25), 50% (p50), and 75% (p75) of the cumulative flow had occurred was recorded. These metrics represent the early, mid, and late season timing of runoff and provide a consistent framework for evaluating shifts in hydrograph timing across years and gages.

Streamflow timing metrics were computed from daily mean discharge. Years were included in the analysis only if records met the same screening requirements used for the mean annual streamflow Mann-Kendall test (see Appendix B). In addition, the dataset could have no more than 14 consecutive days of missing data from April 1 through October 31. The additional screening requirement was added because data gaps can have a large impact when calculating the day of the year when a percentage of annual streamflow has occurred.

Trend analyses of p25, p50, and p75 day of year values were conducted using the Mann-Kendall test and Sen's slope estimator. Sen's slope results are reported in units of days per year (and converted to days per decade where noted), with negative slopes indicating earlier seasonal timing and positive slopes indicating later timing (Table 16).

Table 16. Streamflow timing metrics based on cumulative annual flow percentages (p25, p50, and p75), reported as Day of Year (DOY). Dark gray highlighted rows indicate significant trends (p≤0.05). Light gray highlighted rows indicate marginally significant trends (p≤0.10).

Gage Name	Metric	n	Median of Annual Values (DOY)	DOY Equivalent	p-value	Sen's Slope (days per year)
Agency Creek	p25 DOY	14	139	05/19	0.83	-0.1
Agency Creek	p50 DOY	14	155	06/04	0.66	0.2
Agency Creek	p75 DOY	14	180	06/29	0.27	0.5
Big Eightmile Creek Lower	p25 DOY	10	144	05/24	0.86	1.0
Big Eightmile Creek Lower	p50 DOY	10	163	06/12	0.53	-1.0
Big Eightmile Creek Lower	p75 DOY	10	194	07/13	1.00	0.0
Big Eightmile Creek Upper	p25 DOY	15	149	05/29	1.00	0.0
Big Eightmile Creek Upper	p50 DOY	15	165	06/14	0.45	-0.2
Big Eightmile Creek Upper	p75 DOY	15	192	07/11	0.49	-0.2
Big Springs Creek Lower	p25 DOY	15	133	05/13	0.77	-0.1
Big Springs Creek Lower	p50 DOY	15	195	07/14	0.12	0.6
Big Springs Creek Lower	p75 DOY	15	251	09/08	0.58	0.3
Big Springs Creek Upper	p25 DOY	*15*	*146*	*05/26*	*0.01*	*-0.8*
Big Springs Creek Upper	p50 DOY	15	200	07/19	0.69	-0.3
Big Springs Creek Upper	p75 DOY	15	255	09/12	1.00	0.0
Big Timber Creek nr Leadore	p25 DOY	12	145	05/25	0.58	-1.0
Big Timber Creek nr Leadore	p50 DOY	12	157	06/06	0.54	-0.6
Big Timber Creek nr Leadore	p75 DOY	12	183	07/02	0.63	2.3
Big Timber Creek Upper	p25 DOY	16	147	05/27	0.22	0.5
Big Timber Creek Upper	p50 DOY	16	165	06/14	0.86	0.1
Big Timber Creek Upper	p75 DOY	16	198	07/17	0.39	0.4
Bohannon Creek Lower	p25 DOY	15	142	05/22	0.96	0.2
Bohannon Creek Lower	p50 DOY	15	159	06/08	0.84	0.2
Bohannon Creek Lower	p75 DOY	15	191	07/10	0.14	1.6
Bruno Creek nr Clayton	p25 DOY	54	139	05/19	0.16	0.2
Bruno Creek nr Clayton	p50 DOY	54	155	06/04	0.68	0.0
Bruno Creek nr Clayton	p75 DOY	54	175	06/24	0.96	0.0
Canyon Creek	p25 DOY	15	137	05/17	1.00	0.0
Canyon Creek	p50 DOY	15	173	06/22	0.18	1.0
Canyon Creek	p75 DOY	*15*	*232*	*08/20*	*0.01*	*3.1*
Carmen Creek Lower	p25 DOY	18	140	05/20	0.49	-0.3
Carmen Creek Lower	p50 DOY	18	154	06/03	0.94	0.0
Carmen Creek Lower	p75 DOY	18	166	06/15	0.42	-0.3
Carmen Creek Upper	p25 DOY	11	140	05/20	0.18	-1.3
Carmen Creek Upper	p50 DOY	11	155	06/04	0.21	-1.2
Carmen Creek Upper	p75 DOY	11	173	06/22	0.35	-1.2

Gage Name	Metric	n	Median of Annual Values (DOY)	DOY Equivalent	p-value	Sen's Slope (days per year)
Challis Creek Lower	p25 DOY	13	134	05/14	0.27	-1.0
Challis Creek Lower	p50 DOY	13	149	05/29	0.85	-0.3
Challis Creek Lower	p75 DOY	13	165	06/14	0.67	-0.5
Challis Creek Upper	p25 DOY	*10*	*140*	*05/20*	*0.07*	*-1.9*
Challis Creek Upper	p50 DOY	*10*	*161*	*06/10*	*0.02*	*-2.4*
Challis Creek Upper	p75 DOY	10	201	07/20	0.21	-1.6
East Fork Salmon River	p25 DOY	13	148	05/28	0.85	-0.2
East Fork Salmon River	p50 DOY	13	168	06/17	0.50	-0.8
East Fork Salmon River	p75 DOY	13	200	07/19	0.90	0.1
Eighteenmile Creek	p25 DOY	8	122	05/02	NA	NA
Eighteenmile Creek	p50 DOY	8	158	06/07	NA	NA
Eighteenmile Creek	p75 DOY	8	242	08/30	NA	NA
Fourth of July Creek	p25 DOY	10	142	05/22	0.15	-1.7
Fourth of July Creek	p50 DOY	10	156	06/05	0.15	-1.0
Fourth of July Creek	p75 DOY	10	171	06/20	0.15	-1.7
Hawley Creek Upper	p25 DOY	9	NA	NA	NA	NA
Hawley Creek Upper	p50 DOY	9	NA	NA	NA	NA
Hawley Creek Upper	p75 DOY	9	NA	NA	NA	NA
Hayden Creek	p25 DOY	17	147	05/27	0.14	-0.6
Hayden Creek	p50 DOY	*17*	*162*	*06/11*	*0.05*	*-0.6*
Hayden Creek	p75 DOY	17	184	07/03	0.20	-0.5
Iron Creek	p25 DOY	14	135	05/15	0.30	-0.8
Iron Creek	p50 DOY	14	150	05/30	0.29	-0.8
Iron Creek	p75 DOY	14	175	06/24	0.27	-0.7
Kenney Creek	p25 DOY	15	142	05/22	0.40	-0.3
Kenney Creek	p50 DOY	15	156	06/05	0.80	0.3
Kenney Creek	p75 DOY	*15*	*183*	*07/02*	*0.09*	*1.3*
Lee Creek	p25 DOY	12	139	05/19	0.54	-1.0
Lee Creek	p50 DOY	12	173	06/22	0.37	1.3
Lee Creek	p75 DOY	12	238	08/26	0.49	3.6
Lemhi River at Big Springs	p25 DOY	19	132	05/12	0.55	-0.2
Lemhi River at Big Springs	p50 DOY	*19*	*178*	*06/27*	*0.06*	*-0.8*
Lemhi River at Big Springs	p75 DOY	19	253	09/10	0.17	-0.7
Lemhi River at Cottom Ln	p25 DOY	19	131	05/11	0.94	0.0
Lemhi River at Cottom Ln	p50 DOY	*19*	*176*	*06/25*	*0.07*	*-0.6*
Lemhi River at Cottom Ln	p75 DOY	19	253	09/10	0.40	-0.3
Lemhi River at L1	p25 DOY	10	138	05/18	0.24	1.4
Lemhi River at L1	p50 DOY	10	164	06/13	0.65	0.5
Lemhi River at L1	p75 DOY	10	225	08/13	0.21	-1.9

Gage Name	Metric	n	Median of Annual Values (DOY)	DOY Equivalent	p-value	Sen's Slope (days per year)
Lemhi River at L63	p25 DOY	11	122	05/02	0.43	1.0
Lemhi River at L63	p50 DOY	11	186	07/05	0.76	2.0
Lemhi River at L63	p75 DOY	11	274	10/01	0.81	0.0
Lemhi River bl L5 Diversion	p25 DOY	*32*	*141*	*05/21*	*0.04*	*-0.5*
Lemhi River bl L5 Diversion	p50 DOY	*32*	*164*	*06/13*	*0.02*	*-0.4*
Lemhi River bl L5 Diversion	p75 DOY	32	192	07/11	0.28	-0.3
Lemhi River nr McFarland	p25 DOY	10	128	05/08	0.72	0.6
Lemhi River nr McFarland	p50 DOY	10	176	06/25	0.42	-0.8
Lemhi River nr McFarland	p75 DOY	10	258	09/15	0.24	-2.0
Lemhi River Nr Lemhi	p25 DOY	*65*	*146*	*05/26*	*0.03*	*-0.2*
Lemhi River Nr Lemhi	p50 DOY	*65*	*173*	*06/22*	*0.04*	*-0.1*
Lemhi River Nr Lemhi	p75 DOY	65	228	08/16	0.18	-0.2
Little Springs Creek Lower	p25 DOY	10	136	05/16	0.79	0.6
Little Springs Creek Lower	p50 DOY	10	176	06/25	0.72	0.8
Little Springs Creek Lower	p75 DOY	10	236	08/24	0.93	-0.5
Napias Creek bl Arnett Creek	p25 DOY	27	135	05/15	0.35	-0.2
Napias Creek bl Arnett Creek	p50 DOY	27	151	05/31	0.32	-0.1
Napias Creek bl Arnett Creek	p75 DOY	27	174	06/23	0.71	-0.1
Paasasikwana Naokwaide bl Bruno Ck	p25 DOY	50	132	05/12	0.72	0.0
Paasasikwana Naokwaide bl Bruno Ck	p50 DOY	50	151	05/31	0.26	-0.1
Paasasikwana Naokwaide bl Bruno Ck	p75 DOY	*50*	*173*	*06/22*	*0.06*	*-0.2*
Pahsimeroi River at Ellis	p25 DOY	*41*	*143*	*05/23*	*0.09*	*-0.2*
Pahsimeroi River at Ellis	p50 DOY	*41*	*199*	*07/18*	*0.01*	*-0.3*
Pahsimeroi River at Ellis	p75 DOY	41	264	09/21	0.14	-0.1
Pahsimeroi River at Furey Ln	p25 DOY	5	NA	NA	NA	NA
Pahsimeroi River at Furey Ln	p50 DOY	5	NA	NA	NA	NA
Pahsimeroi River at Furey Ln	p75 DOY	5	NA	NA	NA	NA
Pahsimeroi River at P9	p25 DOY	17	126	05/06	0.87	-0.2
Pahsimeroi River at P9	p50 DOY	17	171	06/20	0.26	-0.8
Pahsimeroi River at P9	p75 DOY	17	266	09/23	0.74	-0.4
Panther Creek at Cobalt	p25 DOY	*14*	*134*	*05/14*	*0.07*	*0.8*
Panther Creek at Cobalt	p50 DOY	*14*	*150*	*05/30*	*0.05*	*0.8*
Panther Creek at Cobalt	p75 DOY	14	178	06/27	0.23	0.7
Patterson Big Springs Upper	p25 DOY	*14*	*141*	*05/21*	*0.01*	*-3.0*
Patterson Big Springs Upper	p50 DOY	14	193	07/12	0.70	0.3
Patterson Big Springs Upper	p75 DOY	*14*	*272*	*09/29*	*0.02*	*1.6*
Pole Creek	p25 DOY	13	143	05/23	0.85	-0.3
Pole Creek	p50 DOY	13	169	06/18	0.20	1.1
Pole Creek	p75 DOY	13	239	08/27	0.18	2.7

Gage Name	Metric	n	Median of Annual Values (DOY)	DOY Equivalent	p-value	Sen's Slope (days per year)
Salmon River at Salmon	p25 DOY	*109*	*144*	*05/24*	*0.08*	*-0.1*
Salmon River at Salmon	p50 DOY	*109*	*165*	*06/14*	*0.06*	*-0.1*
Salmon River at Salmon	p75 DOY	109	200	07/19	0.20	0.0
Salmon River bl Yankee Fork	p25 DOY	25	136	05/16	0.24	-0.3
Salmon River bl Yankee Fork	p50 DOY	25	157	06/06	0.48	-0.1
Salmon River bl Yankee Fork	p75 DOY	25	188	07/07	0.48	-0.1
Salmon River nr Shoup	p25 DOY	23	139	05/19	0.16	-0.3
Salmon River nr Shoup	p50 DOY	23	159	06/08	0.22	-0.3
Salmon River nr Shoup	p75 DOY	23	192	07/11	0.56	-0.2
Texas Creek	p25 DOY	6	NA	NA	NA	NA
Texas Creek	p50 DOY	6	NA	NA	NA	NA
Texas Creek	p75 DOY	6	NA	NA	NA	NA
Thompson Creek nr Clayton	p25 DOY	53	132	05/12	0.42	-0.1
Thompson Creek nr Clayton	p50 DOY	*53*	*150*	*05/30*	*0.02*	*-0.2*
Thompson Creek nr Clayton	p75 DOY	*53*	*172*	*06/21*	*<0.01*	*-0.2*
Valley Creek at Stanley	p25 DOY	*33*	*134*	*05/14*	*0.02*	*-0.4*
Valley Creek at Stanley	p50 DOY	*33*	*156*	*06/05*	*0.03*	*-0.3*
Valley Creek at Stanley	p75 DOY	33	188	07/07	0.21	-0.2
Yankee Fork Salmon River nr Clayton	p25 DOY	13	132	05/12	0.43	0.4
Yankee Fork Salmon River nr Clayton	p50 DOY	13	148	05/28	0.14	0.7
Yankee Fork Salmon River nr Clayton	p75 DOY	13	170	06/19	0.90	0.1

Analysis of p50 day of year values shows that five gages with continuous periods of record exceeding 30 years exhibit statistically significant trends in center of volume (COV) timing (Table 16): Valley Creek at Stanley (n=33, -0.3 days per year), Thompson Creek nr Clayton (n=53, -0.2 days per year), Pahsimeroi River at Ellis (n=41, -0.3 days per year), Lemhi River nr Lemhi (n=65, -0.1 days per year), and Lemhi below L5 (n=32, -0.4 days per year). Given the period of record and spatial distribution, the observed shift in timing may be the result of regional climatic changes, environmental factors, or anthropogenic impacts. However, additional investigations would be necessary to fully identify the mechanisms driving these changes within each tributary.

One notable gage is Challis Creek Upper (n=10, p=0.02, -2.4 days per year). The 2013 Lodgepole Fire, which burned roughly 42% of the watershed, combined with its short period of record, may explain why the COV Sen’s slope is a whole order of magnitude greater than other gages with significant trends.

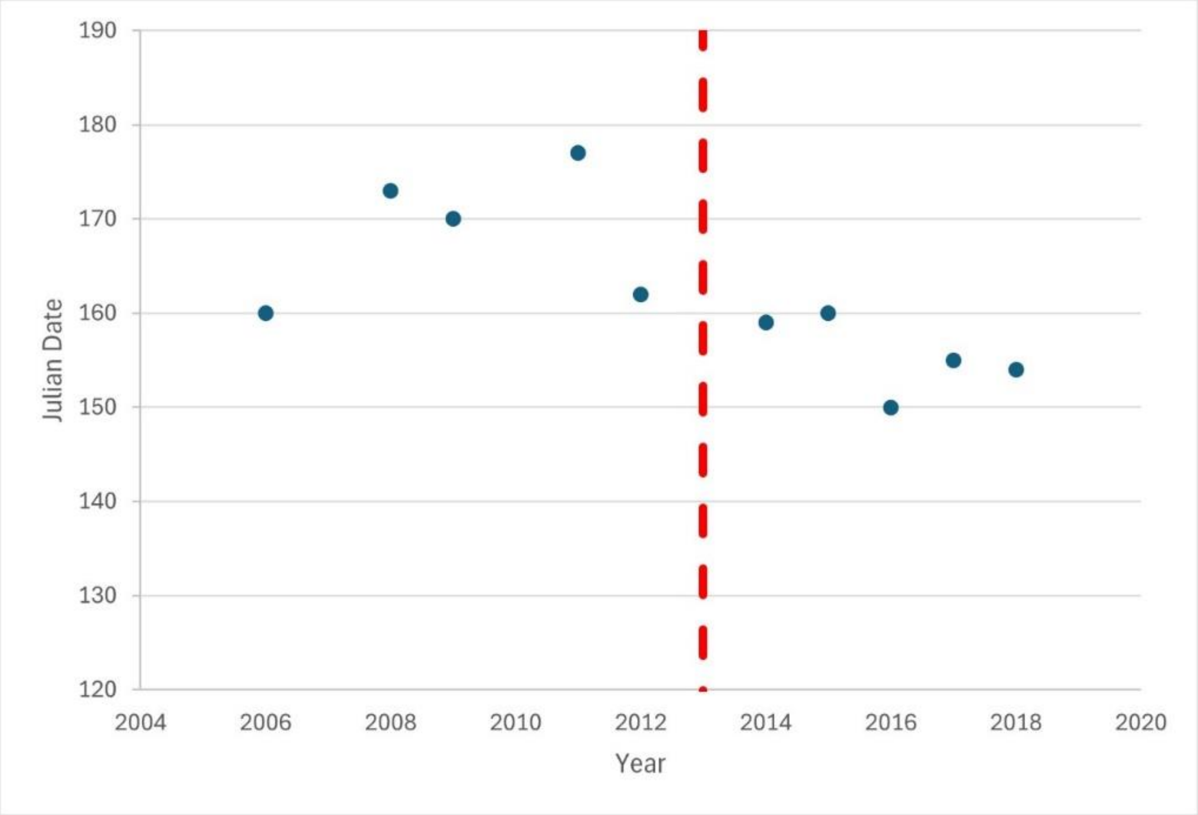


Figure 32. Yearly center of volume timing (blue dots) and timing of Lodgepole Fire (vertical red dashed line) at the Challis Creek Upper gage.

Additionally, two of the three gages expressing marginally significant ($p<0.10$) trends have moderate periods of record: Lemhi River at Big Springs (n=19, -0.8 days per year) and Lemhi River at Cottom Ln (n=19, -0.6 days per year) (Table 16). While these records are shorter, the magnitude and consistency of the negative slopes may indicate a tendency towards an earlier center of volume date in the upper Lemhi subbasin. However, the effects of the 2021 drought and the more recent minor drought may also be applying pressure on these trends, underscoring the need for continued monitoring before drawing broader conclusions.

It is important to recognize that these findings are constrained by the length and characteristics of the available periods of record. As such, the estimated rate of change in days per decade should be interpreted as an indication of what might occur under similar future conditions, rather than a definitive forecast. As new anomalies or persistent shifts present themselves, they may strengthen, weaken, or reverse the current timing trajectories. This analysis is best viewed as a tool to further improve our understanding of complex water resource issues and help inform future water management strategies and implementation efforts.

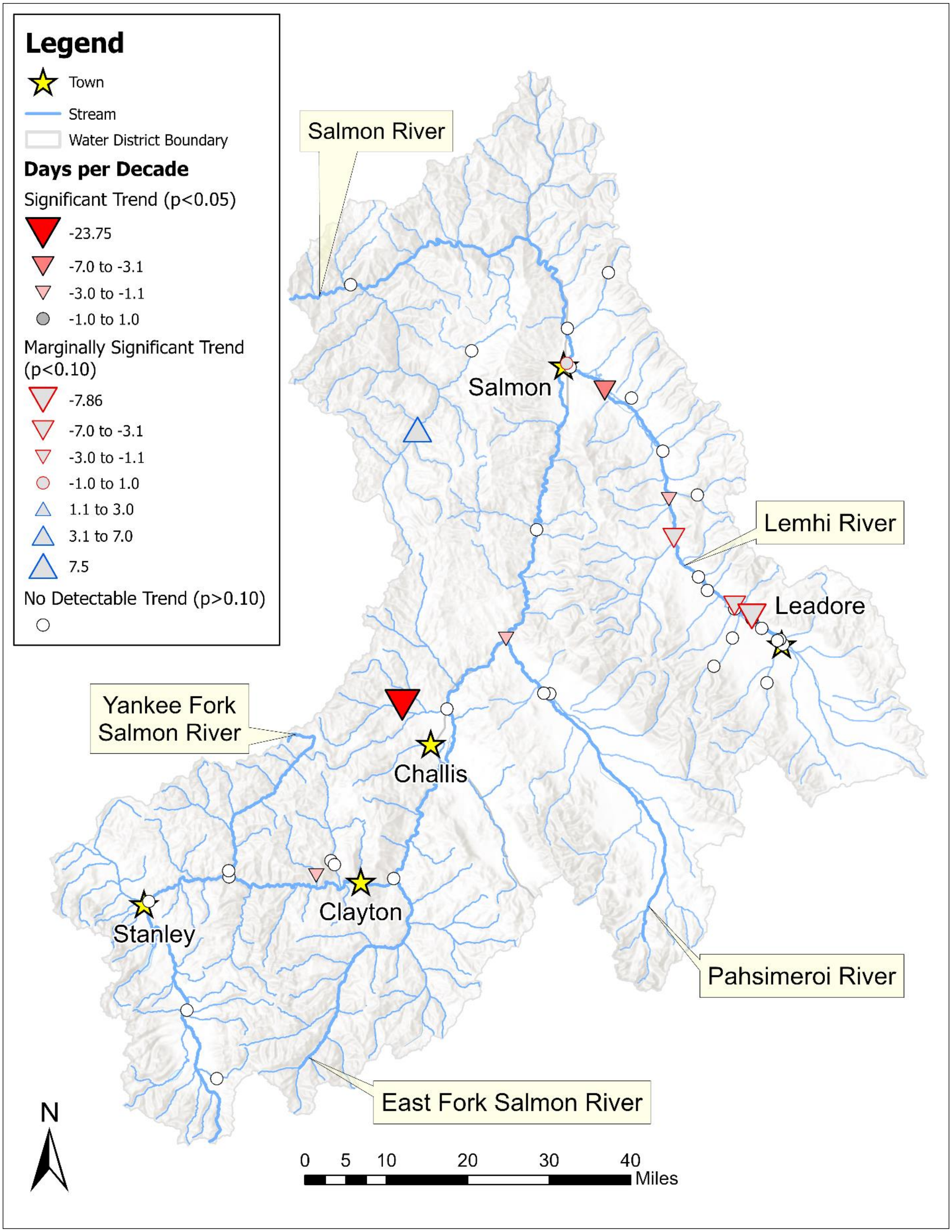


Figure 33. Change in timing of 50% of cumulative April 1-October 31 streamflow in the Upper Salmon Basin

Task 11b. Trends in Groundwater Levels

Regarding groundwater trends, stakeholders asked the following questions:

1) What are the impacts of the 2021 drought on groundwater level trend analyses? See "Long-term trends in groundwater levels" and "Groundwater level drought sensitivity analysis".
2) Were there any trends in groundwater level seasonality? See "Trends in groundwater level seasonality".
3) What are the impacts of water right curtailment on wells near diversion ditches or flood irrigated fields? See "Water right curtailment sensitivity analysis".

Long-term trends in groundwater Levels

Groundwater level analyses were conducted using a two-step workflow consisting of metric-specific data screening followed by long-term trend, drought sensitivity, and seasonality evaluations on the finalized datasets. Water level measurements were screened for completeness, continuity, and pumping effects by restricting analyses to wells meeting predefined minimum data density and period of record requirements, removing measurements influenced by documented or inferred pumping, and limiting the dataset to maximum daily groundwater levels to reduce remaining pumping artifacts. Following screening (Appendix B), wells were included in each analysis only if they met the necessary record length thresholds.

Groundwater levels from 1995-1998, collected as part of the Donato (1998) study, provides some of the earliest and most spatially consistent monitoring coverage across wells that continue to be measured today, making it the most appropriate baseline for evaluating longer-term changes. For each well, median depth to water was evaluated for five periods, January-March (Q1), April-June (Q2), July-September (Q3), October-December (Q4), and January-December (Annual), and the change in median water levels between the two periods was computed (Table 17). Q1 groundwater levels represent conditions during minimal human influence from diversions, irrigation practices, and other anthropogenic stressors. In contrast, Q3 groundwater levels characterize mid to late summer conditions, when human influence on groundwater levels is most pronounced. In addition to Table 17, changes to groundwater levels during the Q1 and Q3 periods are visualized in Figure 35 and Figure 36.

Table 17. Change in median groundwater levels between 1995-1998 and 2011-2020, by quarter. Values were calculated for each well, and the median of those values are displayed in this table.

Location	Q1 Change	Q2 Change	Q3 Change	Q4 Change	Annual Change
Lemhi Basin	-0.71	-0.62	-1.3	-0.91	-0.88
Upper Lemhi Subbasin	-1.6	-2.08	-4.94	-3.58	-3.49
Lower Lemhi Subbasin	0.00	0.45	-0.60	0.18	0.15

Median annual groundwater level changes, 1995-1998 and 2011-2020

At the basin scale, median annual change indicates a net decline in groundwater levels (-0.88 ft). By subbasin, the Upper Lemhi shows larger declines (-3.49 ft), whereas the Lower Lemhi Subbasin is generally stable between time periods (+0.15 ft) (Table 17).

In the Upper Lemhi Subbasin, all six wells near Leadore show a decline in median annual groundwater levels between 1995-1998 and 2011-2020. Declines range from -2.6 to -5.9 ft (Figure 34), while the other two wells had declines of less than one foot.

In the mid-basin, below the confluence of Big Eightmile Creek to the Upper-Lower Basin Divide, eight of the eleven wells show declines ranging from -3.09 to -11.5 ft. The remaining three wells show slight increases ranging from +0.05 to +1.31 ft (Figure 34).

Downstream of the constriction, groundwater behaves differently. Nine of the 15 wells between Tendoy and the confluence with the Salmon River show increases in median water levels ranging from +0.1 to +2.9 ft, while six wells show decreases ranging from -0.02 to -2.13 ft (Figure 34). Given that groundwater and surface water are strongly connected in the Lemhi Basin, this spatial contrast is notable. While wells upstream of the constriction generally show declining groundwater levels between the two time periods analyzed, several wells downstream show the opposite response. This pattern suggests that the basin constriction may influence how groundwater responds to changes in streamflow, recharge, or historical and current water management practices. While the lower subbasin may benefit from localized recharge or conditions that promote groundwater retention, the upper subbasin may be more sensitive to surface water availability and recharge.

Comparison of groundwater level changes by quarter

Q1 changes show a muted but still basin-wide deepening (median of -0.71 ft). The Upper Lemhi Subbasin again exhibits larger declines (-1.6 ft), while the Lower Lemhi Subbasin is essentially stable (0.00 ft) (Table 17). Q3 shows stronger seasonal stress (-1.3 ft) across the basin. The Upper Lemhi Subbasin shows pronounced summer deepening (-4.94 ft) while the Lower Lemhi subbasin experiences a median decline of -0.6 ft.

Comparing Q1 (Figure 35) and annual changes reveals notable divergences. The largest difference between Q1 and annual depth to water occurs at a well just south of the town of Lemhi (18N 24E 33ACB1), with a difference of approximately five feet (-2.44 ft in Q1 versus -8.54 ft annually). Near the constriction, 18N 24E 20ADD1 shows a difference of approximately 3.5 ft (-12.75 ft in Q1 vs -9.11 ft annually).

During Q3 (Figure 36), several Upper Lemhi Subbasin wells decline far more than the annual change. For example, a well east of Leadore (16N 26E 21ACA1), shows a Q3 change of -21.6 ft compared to an annual change of -2.6 ft, and 18N 24E 33ACB1 (south of Lemhi) shows a Q3 change of -15.11 ft compared to an annual change of -8.54 ft. Notably, 16N 26E 26ABB1 deviates from this trend with a Q3 change of +10.08 ft while the annual change is -3.97 ft. In the Lower Lemhi Subbasin, some sites exhibit seasonal reversals. Well 20N 23E 03CBA2 shows a Q3 change of -1.4 ft but an annual change of +2.61 ft, illustrating how summer pumping/recharge dynamics can mask or reverse annual trends.

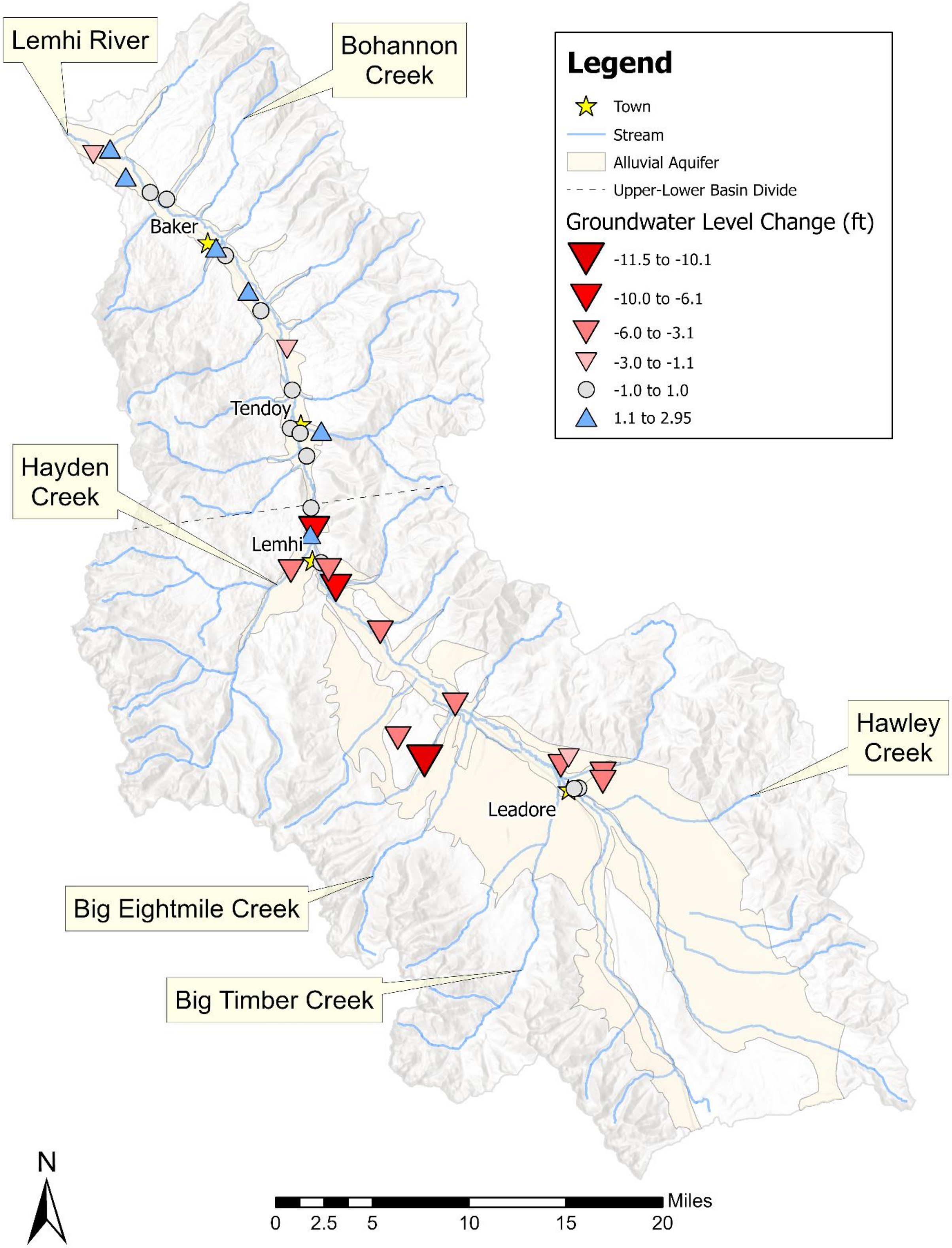


Figure 34. Changes in median annual groundwater levels in the Lemhi Basin: 2011-2020 compared to 1995-1998

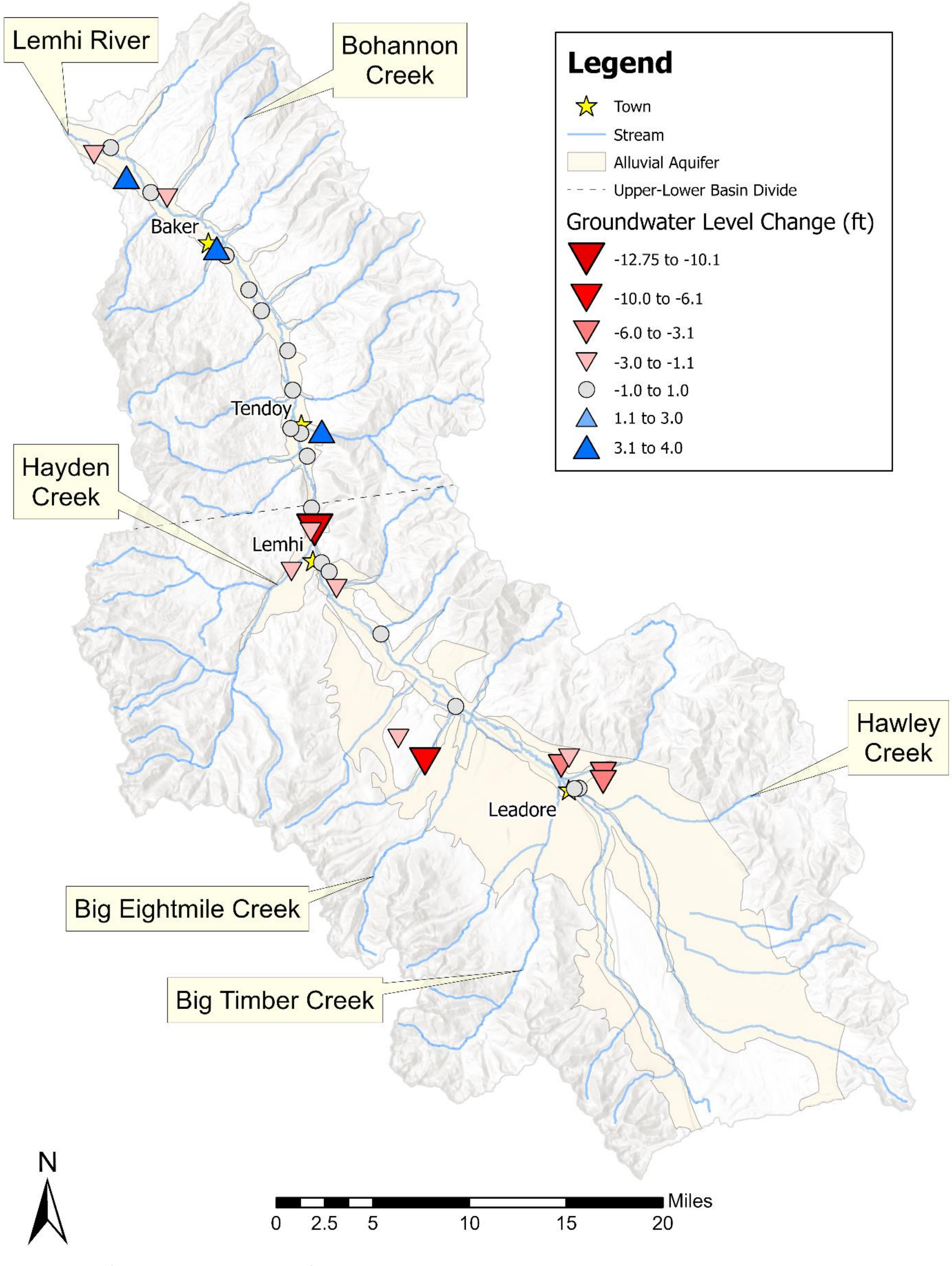


Figure 35. Changes in median Q1 groundwater levels in the Lemhi Basin: 2011-2020 compared to 1995-1998

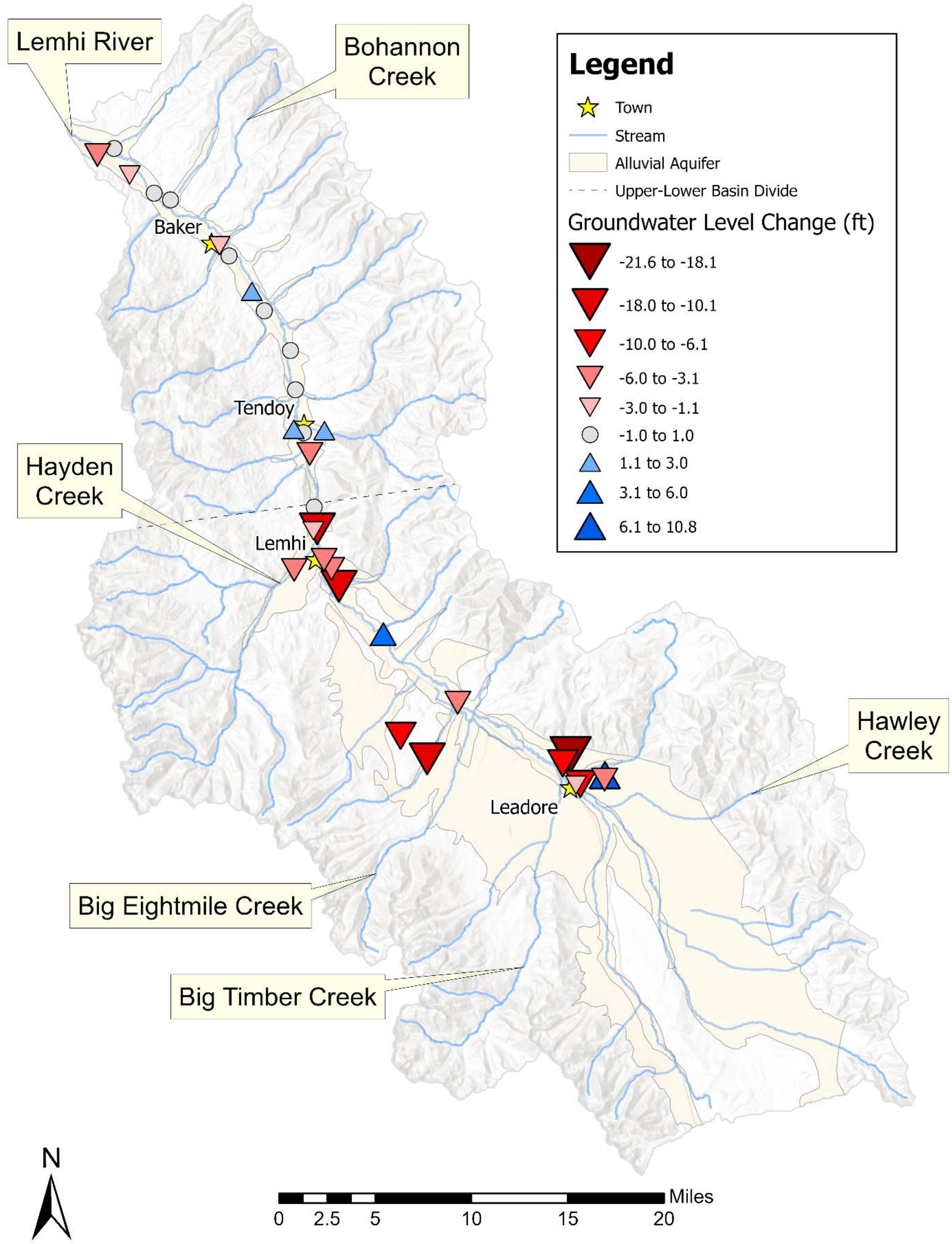


Figure 36. Changes in median Q3 groundwater levels in the Lemhi Basin: 2011-2020 compared to 1995-1998

Groundwater level drought sensitivity analysis

Table 18 depicts the median change in groundwater levels at each Lemhi Basin well between the period of 2011 to 2020, the extreme drought year (2021), moderate drought year (2022), and recovery phase (2023). The median water level change for all wells in the Lemhi Basin, as well as the Upper Lemhi Subbasin and Lower Lemhi Subbasin (see the Upper-Lower Basin Divide in Figure 34), are also summarized. Basin and Subbasin medians were derived by taking the median of the individual well medians for each year.

Table 18. Median groundwater level change, by year, relative to 2011-2020 median groundwater levels in the Lemhi Basin

Site	2021 Change (ft)	2022 Change (ft)	2023 Change (ft)
Lemhi Basin	-0.20	-0.15	0.59
Upper Lemhi Subbasin	-0.91	-0.15	0.60
Lower Lemhi Subbasin	0.09	-0.04	0.59
21N 23E 30DAC1	-0.02	-0.76	0.66
21N 22E 10CCA1	0.98	2.05	1.21
21N 22E 09DDB1	0.07	0.56	0.53
20N 24E 31DDC1	-0.21	1.19	1.28
20N 23E 14DDB1	-0.92	-0.04	0.59
20N 23E 11DBB2	0.09	-1.36	-0.49
20N 23E 11DBB1	0.14	-0.81	0.47
20N 23E 11ADD2	-0.36	-0.61	0.00
20N 23E 11ADD1	0.43	-0.68	0.51
20N 23E 03CBA2	0.32	0.45	0.58
19N 24E 32ADC1	0.60	0.36	3.76
19N 24E 30AAA2	6.11	3.79	4.18
19N 24E 29BDA1	-0.55	-0.43	1.38
18N 24E 33ACB1	-3.58	-2.64	-6.38
18N 24E 31ACD1	-2.16	0.28	2.03
18N 24E 21BCD1	-1.05	0.88	1.22
18N 24E 20ADD1	-2.46	-0.02	-0.09
17N 24E 13CBD1	-0.19	0.00	0.65
17N 24E 04ADC1	1.32	-0.29	2.04
16N 26E 27CCB1	-0.77	-0.60	-0.17
16N 26E 21CAC1	-0.52	-0.15	0.10
16N 26E 20CDD1	-0.09	-0.25	0.56
16N 25E 03BCC1	-1.16	-0.15	0.72

In the Upper Lemhi Subbasin, median groundwater levels declined in 2021 (-0.91 ft) and 2022 (-0.15 ft) followed by a modest rise in 2023 (+0.60 ft) (Table 18). Though some wells reflect persistent declines, most notably 18N 24E 33ACB1 (-3.58 ft, -2.64 ft, -6.38 ft), the majority of wells recovered back to baseline or were shallower than baseline conditions by 2023.

In the Lower Lemhi Subbasin, median groundwater levels remained fairly stable in 2021 (+0.09 ft) and 2022 (-0.04 ft) and turned positive in 2023 (+0.59 ft). Aside from 20N 23E 11DBB1, all wells had shallower water levels in 2023 than the 2011-2020 baseline.

At the basin scale, annual changes indicate a slight basin-wide decline in 2021 (-0.20 ft) and 2022 (-0.15 ft) and a net rise in 2023 (+0.59 ft). Overall, 2023 shows clear basin improvement, although some upper subbasin wells have been slower to recover, limiting the strength of the overall rebound.

Trends in groundwater level seasonality

To evaluate potential shifts in the seasonal timing of groundwater levels between historical and recent conditions, the day of year (DOY) corresponding to the shallowest (minimum DTW) and deepest (maximum DTW) groundwater levels was computed for each well. The median DOY of these metrics was then calculated for the 1995-1998 and 2011-2020 periods, using only well years that satisfied predefined data completeness and continuity screening criteria. The basin and subbasin medians shown are the aggregated median of the individual well medians for each metric. Positive values in Table 19 indicate that seasonal groundwater extremes occurred later in the year during 2011-2020 when compared to the 1995-1998 period.

It is important to note that all wells were non-instrumented during the 1995-1998 period, and 17 wells were non-instrumented during 2011–2020. Non-instrumented wells were typically measured approximately once every two weeks, and measurement dates did not align year to year. As a result, the uncertainty in the DOY associated with a groundwater level extreme may be as large as two weeks, or potentially longer if minimum or maximum measurements were missed. Despite this uncertainty, the timing of groundwater level extremes, and the changes in timing, are summarized in Table 19.

Table 19. Changes in timing of groundwater levels between 1995-1998 and 2011-2020

Basin	Median Date (1995 - 1998) Shallowest DTW	Median Date (2011 - 2020) Shallowest DTW	Change (days)	Median Date (1995 - 1998) Deepest DTW	Median Date (2011 - 2020) Deepest DTW	Change (days)
Lemhi Basin	07/17	06/21	-26	08/24	08/17	-7
Upper Lemhi Subbasin	07/11	06/29	-12	09/09	08/17	-23
Lower Lemhi Subbasin	07/24	06/18	-36	08/12	08/16	4

Negative values in Table 19 indicate that seasonal timing of groundwater level extremes has shifted earlier across most of the Lemhi Basin, particularly when depth to groundwater is at its shallowest. However, interpretation of these changes is complicated by the considerable measurement uncertainty associated with non-instrumented wells. In addition, the observed differences between the 1995-1998 and 2011-2020 periods may be an artifact of the transition from non-instrumented measurements during the earlier period of record to largely instrumented, high frequency data collection during the later period. This shift in monitoring methods may influence the apparent timing of annual groundwater extremes and is especially true if minimums and maximums were not captured in the earlier dataset. As more years of continuous pressure transducer data are collected, a more robust assessment of long-term changes in seasonal groundwater timing extremes will be possible.

To evaluate potential changes in groundwater extremes, IDWR performed Mann-Kendall and Sen's slope analyses over the period of record for wells during which data loggers were installed (Table 20). Mann-Kendall tests and Sen's slope analyses were run for three metrics at each well: annual minimum, annual median, and annual maximum.

Table 20. Trends in annual groundwater level metrics for wells with continuous data loggers, 2011-2020. Dark gray highlighted cells indicate significant trends (p≤0.05). Light gray highlighted cells indicate marginally significant trends (p≤0.10).

Well ID	n	Annual Min Sen's Slope (ft/yr)	p-value	Annual Median Sen's Slope (ft/yr)	p-value	Annual Max Sen's Slope (ft/yr)	p-value
21N 23E 30DAC1	9	*0.05*	*0.03*	0.02	0.92	-0.04	0.76
21N 22E 10CCA1	13	-0.13	0.44	*-0.17*	*0.06*	*-0.16*	*0.04*
21N 22E 09DDB1	6	*0.19*	*0.06*	-0.20	0.14	0.12	0.27
20N 24E 31DDC1	8	0.06	0.40	0.01	0.90	-0.04	0.91
20N 23E 14DDB1	7	0.11	0.24	0.03	0.77	-0.03	0.56
20N 23E 11DBB2	5	-0.31	0.48	-0.43	0.48	*1.83*	*0.08*
20N 23E 11DBB1	6	-0.43	0.47	-0.52	0.27	1.06	0.14
20N 23E 11ADD2	4	*0.09*	*0.08*	0.14	0.33	*0.38*	*0.08*
20N 23E 11ADD1	6	0.05	0.27	-0.04	0.72	0.20	0.27
20N 23E 03CBA2	13	*-0.04*	*<0.01*	-0.08	0.13	0.02	0.68
19N 24E 32ADC1	9	*0.25*	*0.05*	0.22	0.76	*-0.11*	*0.03*
19N 24E 30AAA2	7	-1.82	0.14	-1.33	0.14	-0.82	0.14
19N 24E 29BDA1	7	*0.12*	*0.07*	0.04	0.77	-0.14	0.14
18N 24E 33ACB1	6	*0.44*	*0.06*	0.24	0.47	0.18	0.47
18N 24E 31ACD1	6	-0.06	0.47	-0.10	0.72	0.10	1.00
18N 24E 21BCD1	10	0.11	0.29	0.19	0.22	0.03	0.60
18N 24E 20ADD1	7	0.11	0.77	-0.30	0.56	-0.10	0.77
17N 24E 13CBD1	8	0.03	0.72	-0.07	0.55	*0.99*	*0.01*
17N 24E 04ADC1	7	-0.01	0.56	0.06	0.36	*-0.38*	*0.07*
16N 26E 27CCB1	7	*0.17*	*0.03*	0.17	0.14	0.15	0.24
16N 26E 21CAC1	11	0.03	0.21	0.03	0.45	-0.02	0.65
16N 26E 20CDD1	9	0.11	0.18	0.00	0.92	-0.02	0.48
16N 25E 20BDD1	4	1.73	0.75	2.17	0.75	-0.97	1.00
16N 25E 03BCC1	7	0.11	0.24	0.12	0.24	*0.83*	*0.07*

Across the Lemhi Basin, few statistically significant trends are observed, and those that are present are generally low in magnitude and mixed in direction, with no clear spatial pattern (Table 20). Given the short periods of record and limited statistical confidence, observed variability likely reflects short-term hydrogeologic fluctuations rather than basin-scale trends. Continued monitoring is needed to further assess long-term conditions.

Conclusions for Streamflow and Groundwater Trend Analyses

Trend analyses conducted for streamflow and groundwater levels indicate spatial variability in hydrologic patterns in the Upper Salmon Basin. In the Lemhi Basin, several tributaries exhibit statistically significant or marginally significant declines in April-October streamflow metrics, as well as the mainstem Lemhi River during winter low flow conditions. Minor tributaries and the mainstem Salmon River in the Upper Salmon Basin show more variability in April-October streamflow metrics, suggesting changes in streamflow may be localized in the Lemhi Basin rather than basin-wide. Groundwater level comparisons between the 1995-1998 and 2011-2020 periods reveal a general decline of groundwater in the Upper Lemhi Subbasin, contrasted by the more stable or slightly rising conditions downstream of the basin constriction. The influence of the 2021 drought is evident in both the groundwater and surface water datasets, with signs of recovery by 2023 in much of the Lemhi Basin.

Collectively, these findings highlight the importance of continued long-term monitoring to distinguish short-term variability from basin-scale trends. As additional years of data become available, the baseline conditions and analytical framework established in this report will support more robust evaluation of habitat restoration projects, improve our understanding of drought sensitivity and recovery, and inform adaptive water management strategies across the Upper Salmon Basin.

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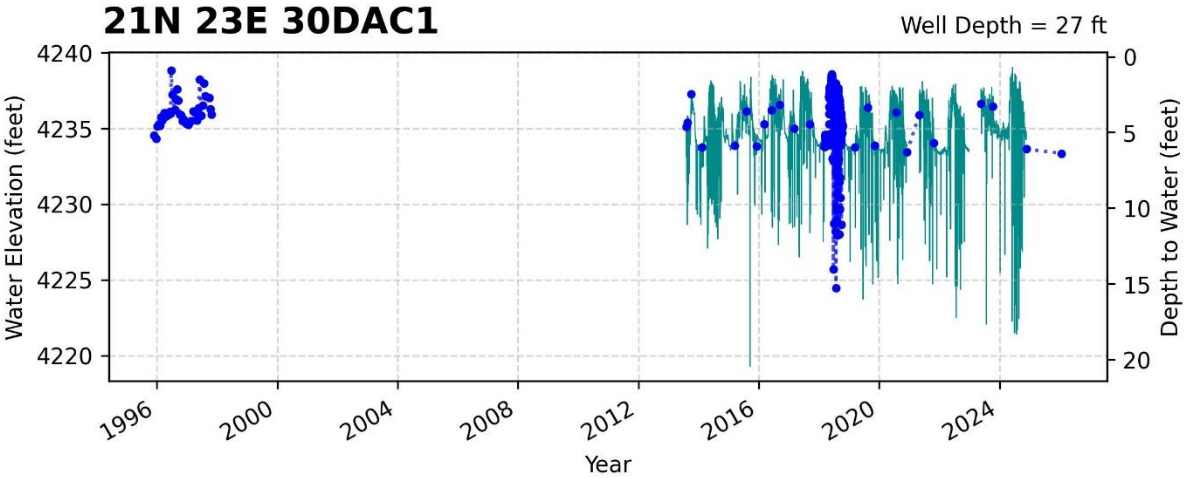
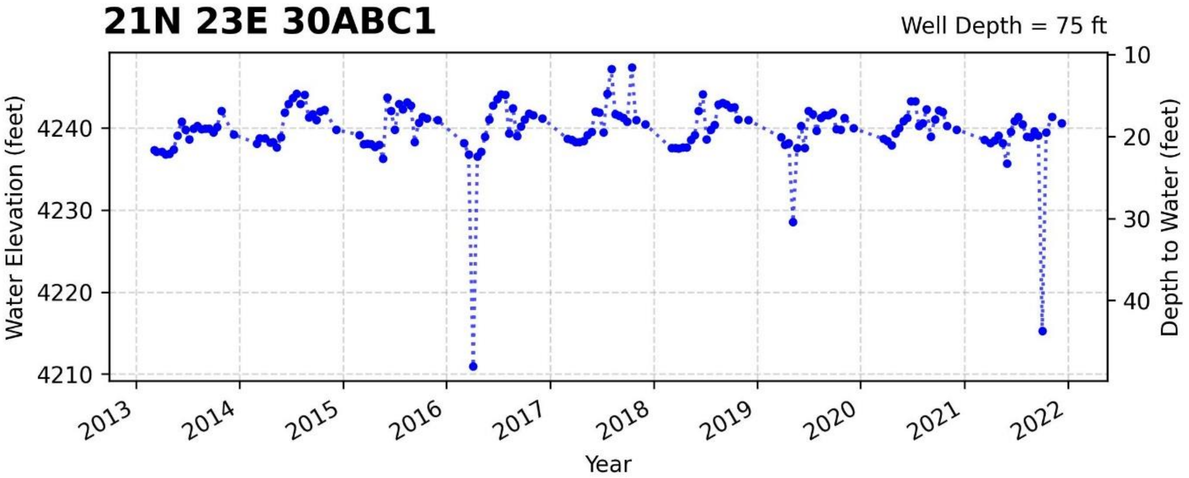
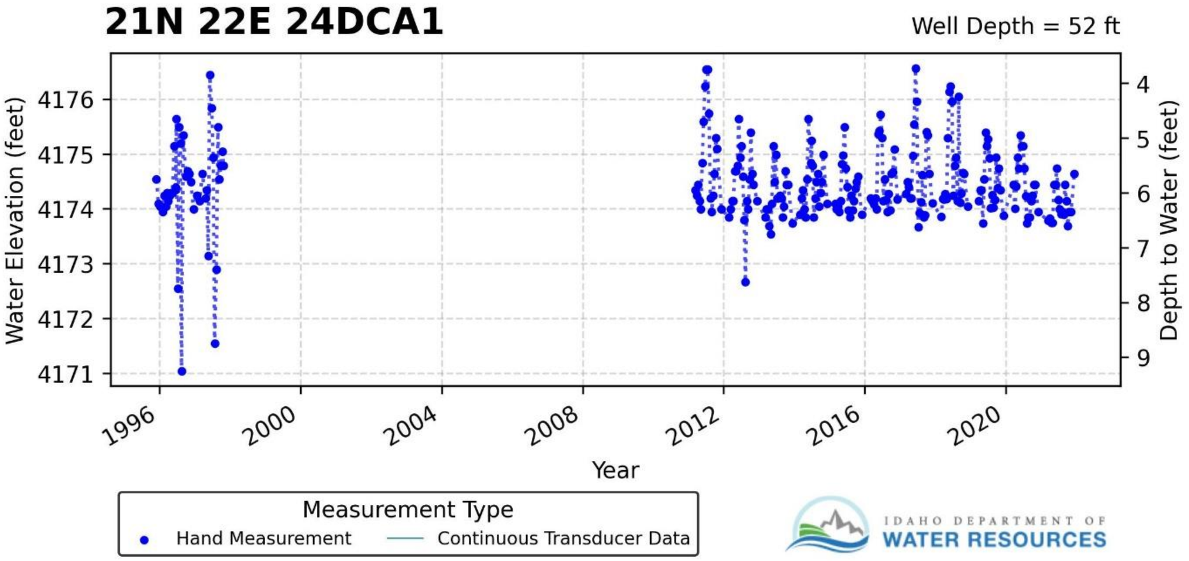
APPENDIX A

Lower Lemhi Subbasin Well Hydrographs







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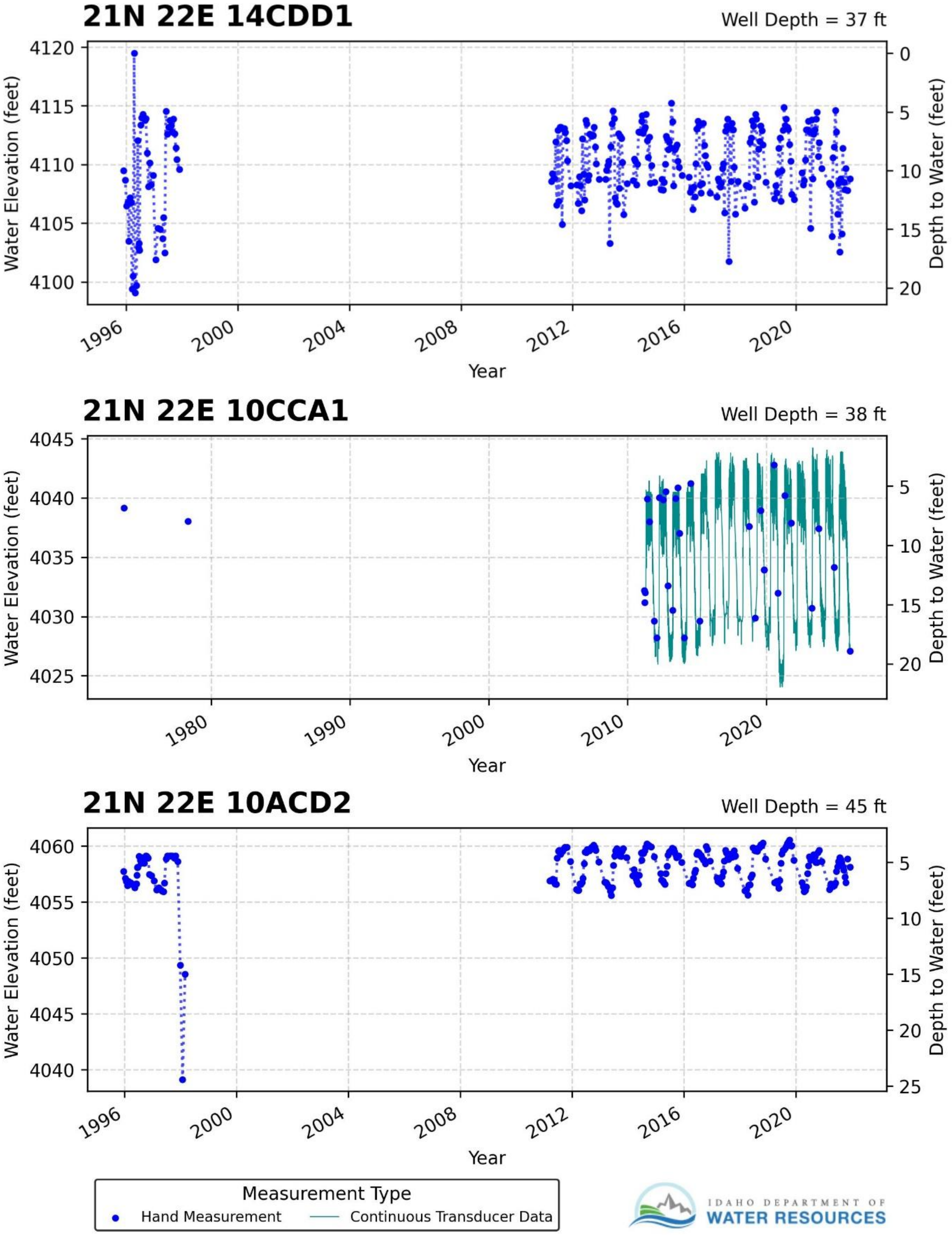

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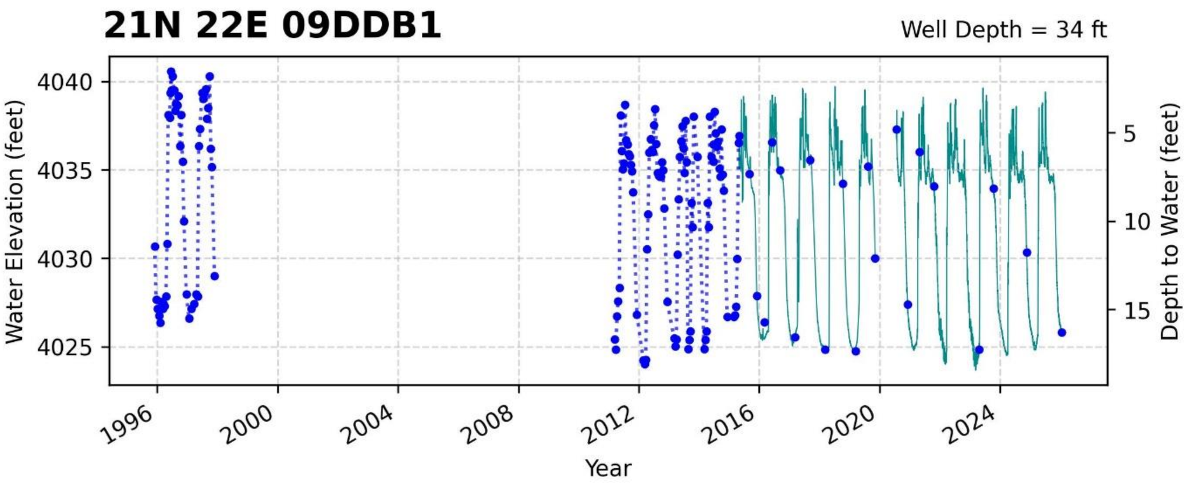
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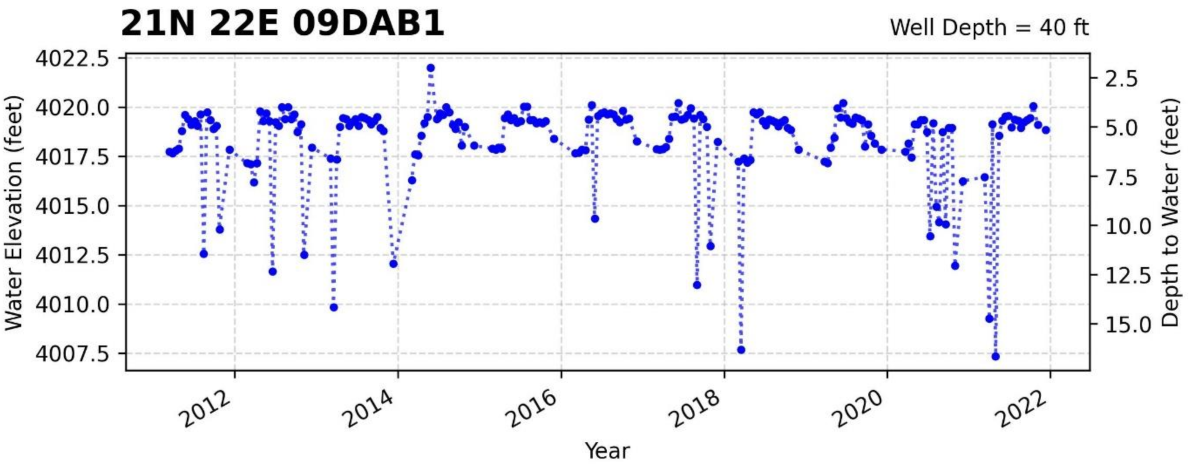
Water Elevation (feet)
4040
4035
4030
4025
Depth to Water (feet)
5
10
15
1996
2000
2004
2008
2012
2016
2020
2024
Year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4015.0
4012.5
4010.0
4007.5
Depth to Water (feet)
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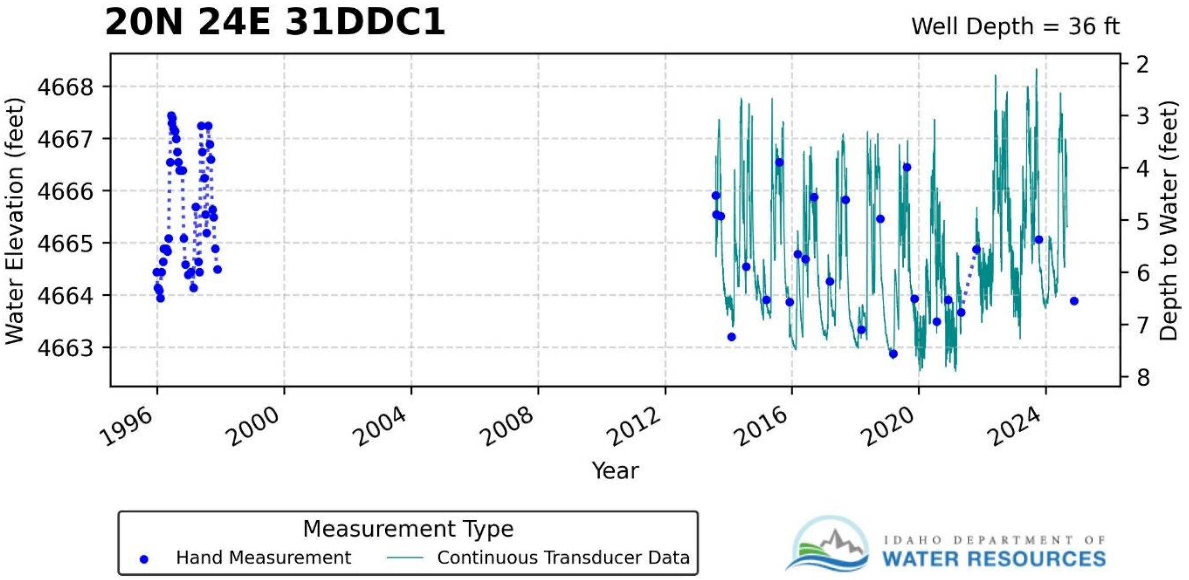
5.0
7.5
10.0
12.5
15.0
2012
2014
2016
2018
2020
2022
Year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Well Depth = 36 ft
Water Elevation (feet)
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4667
4666
4665
4664
4663
Depth to Water (feet)
2
3
4
5
6
7
8
1996
2000
2004
2008
2012
2016
2020
2024
Year
Measurement Type
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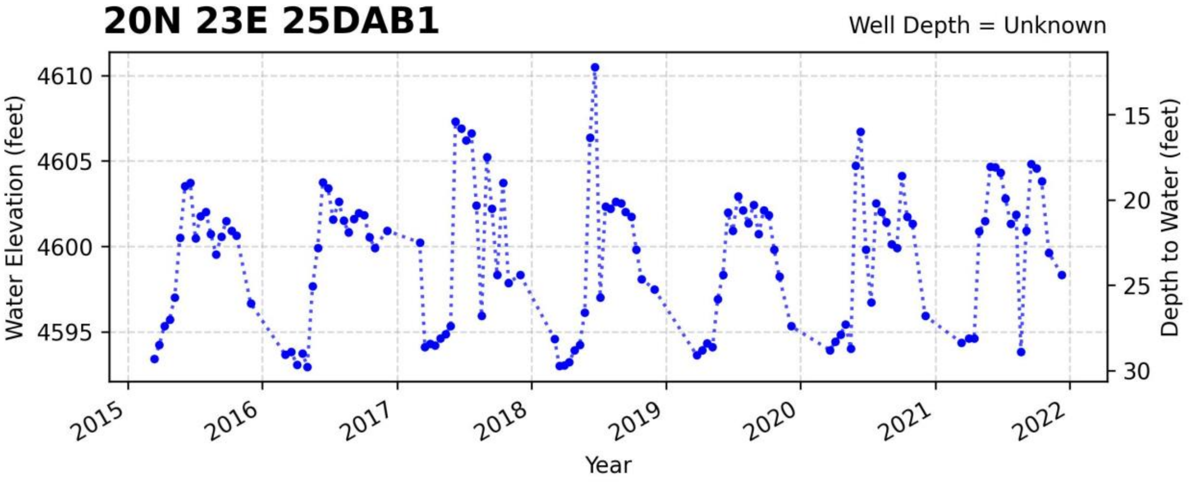
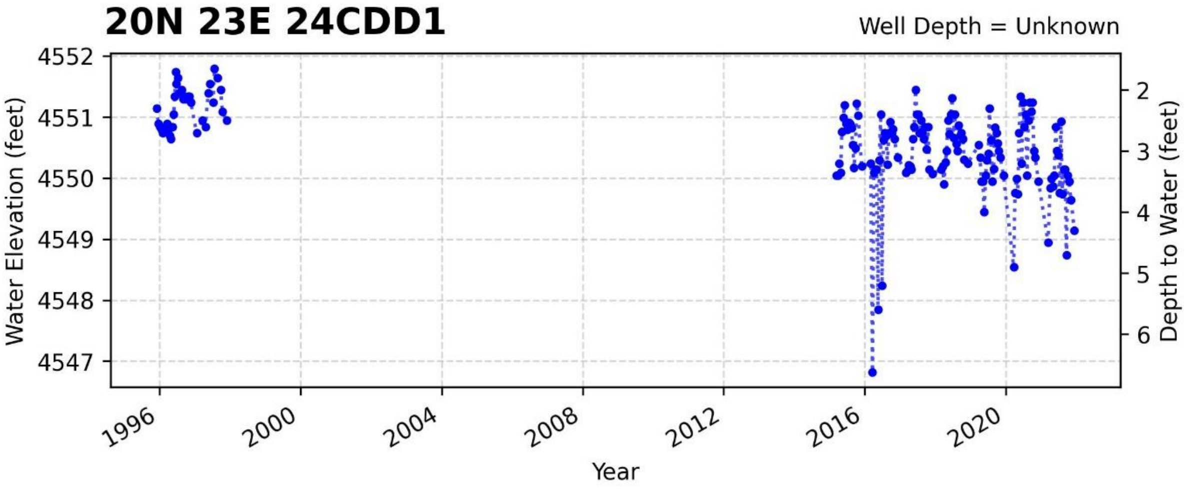
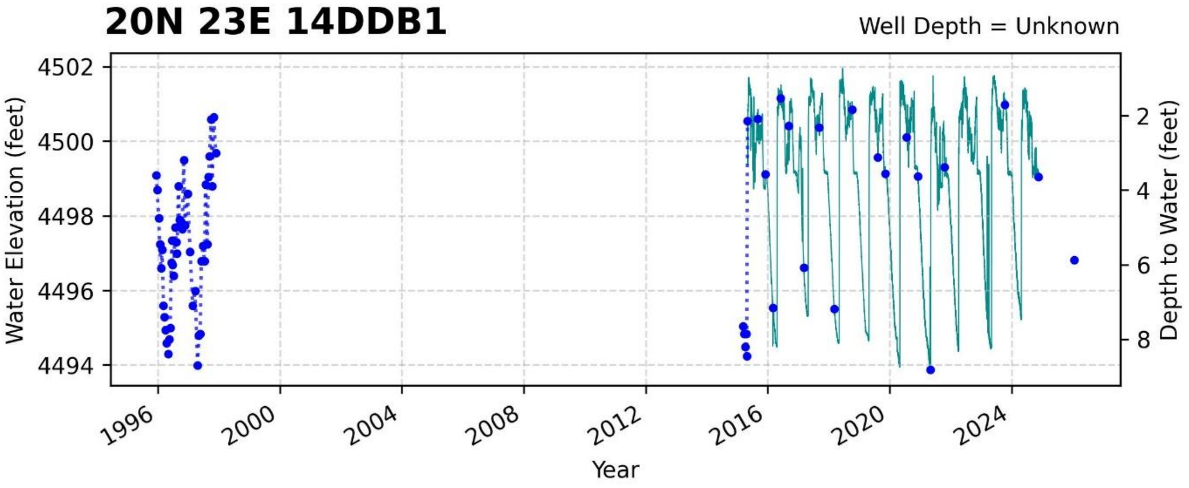
Continuous Transducer Data







Measurement Type

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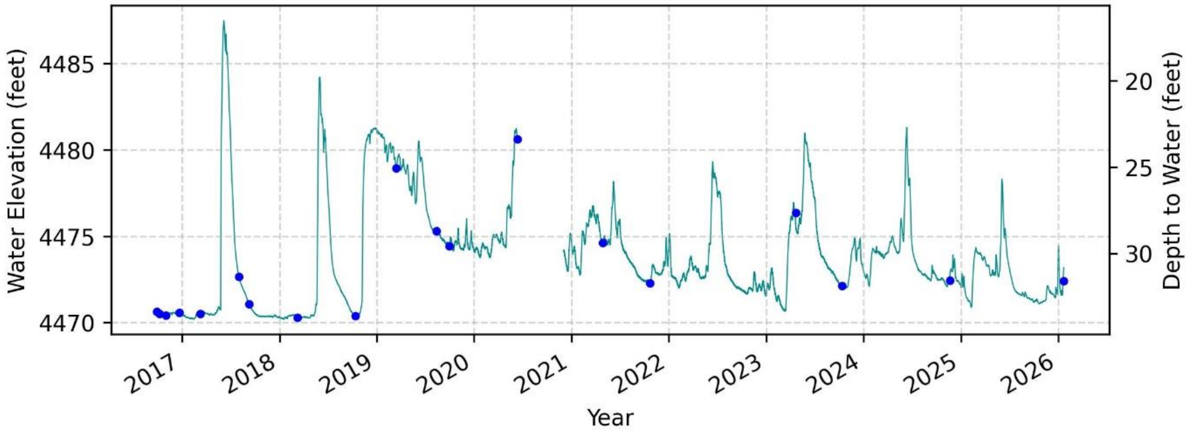

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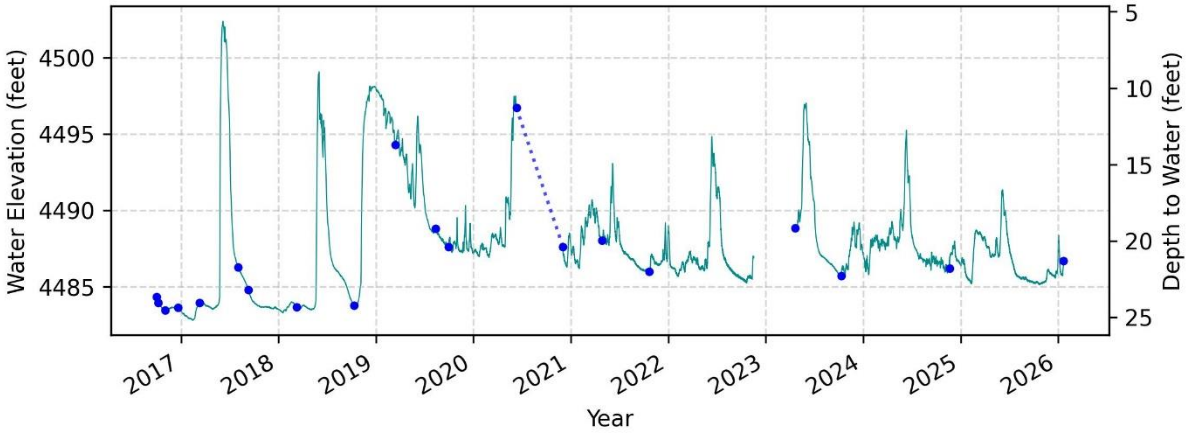

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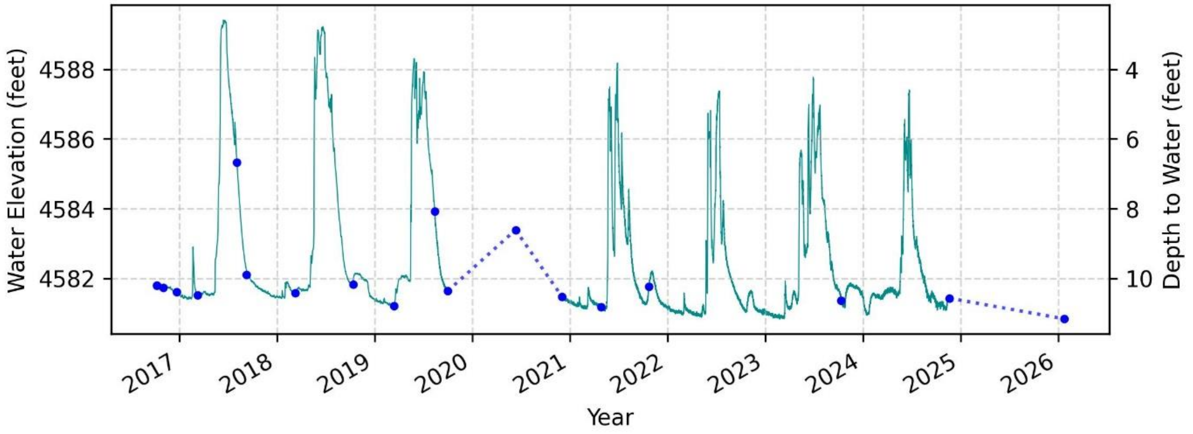

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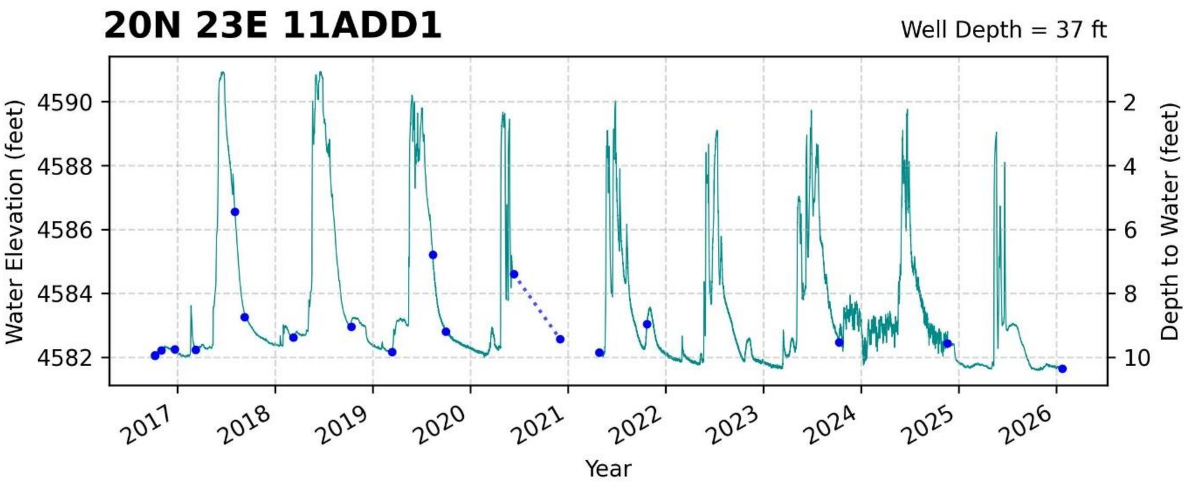

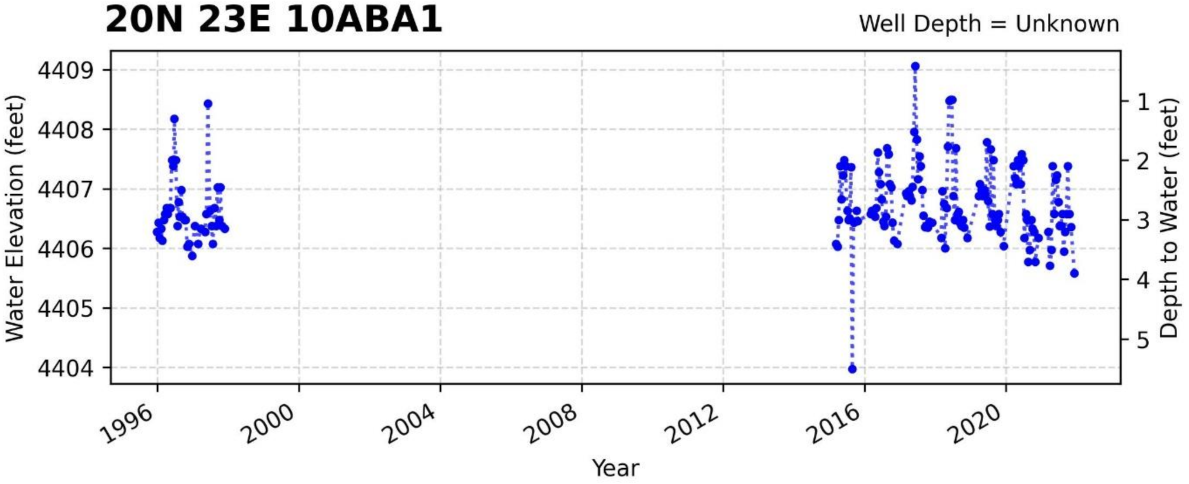

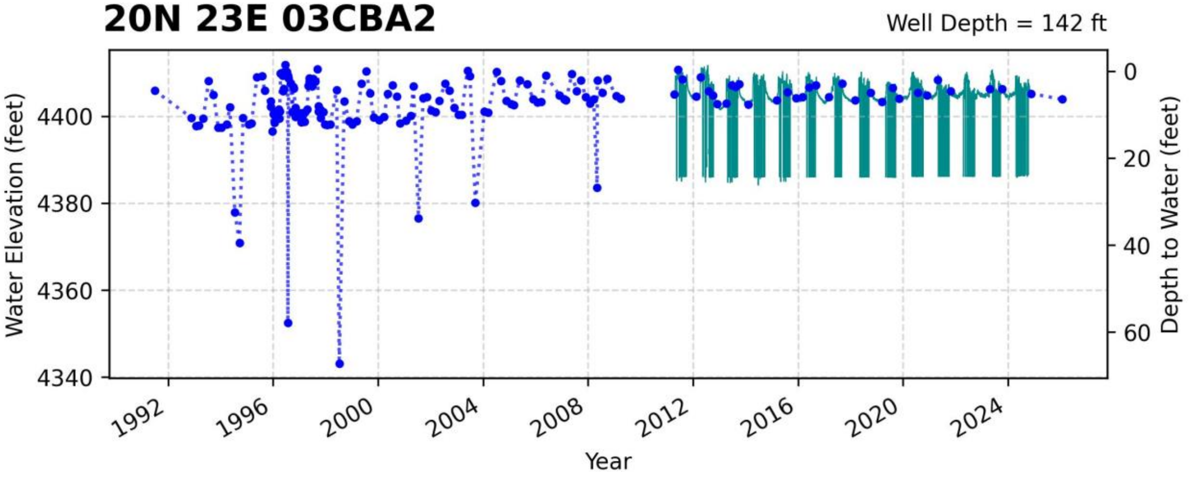

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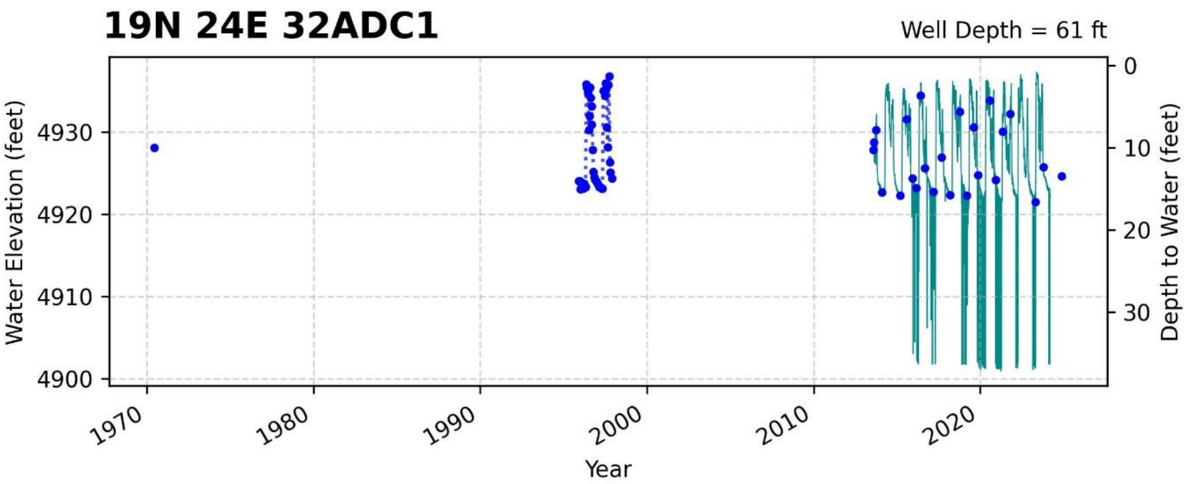
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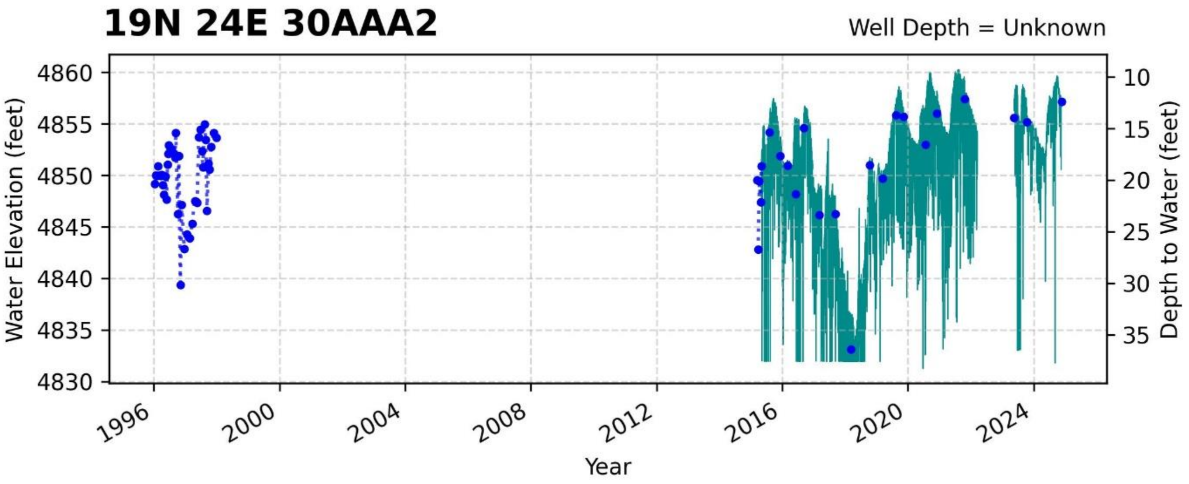
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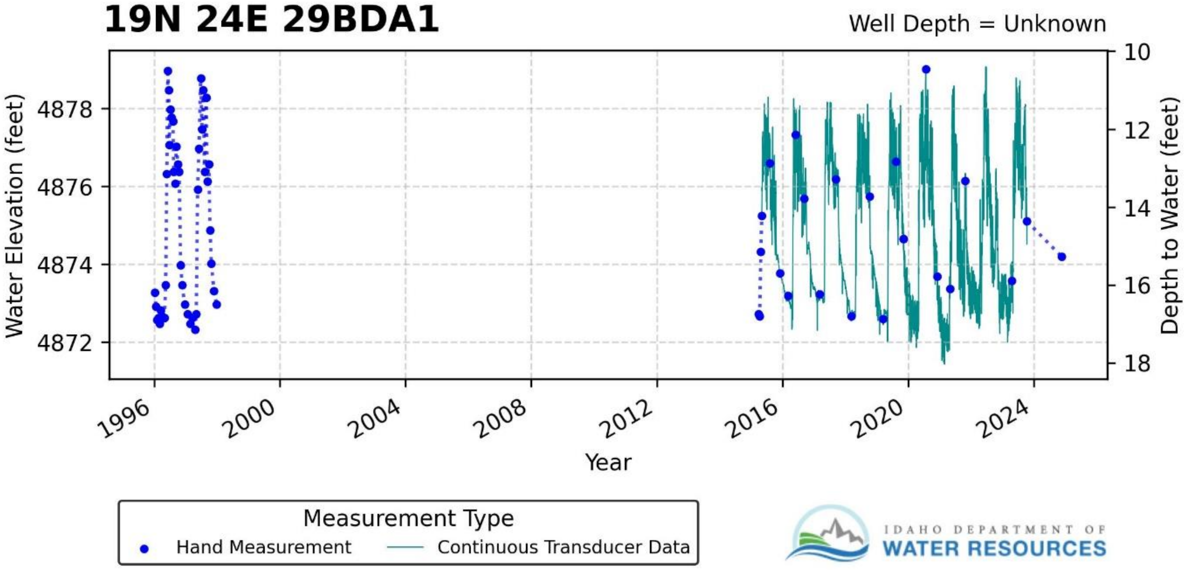
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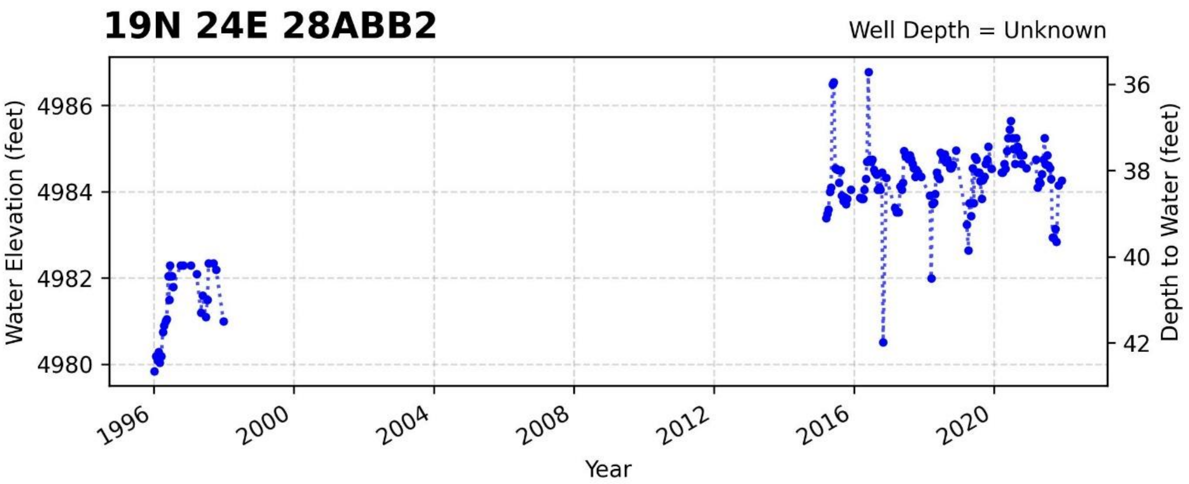

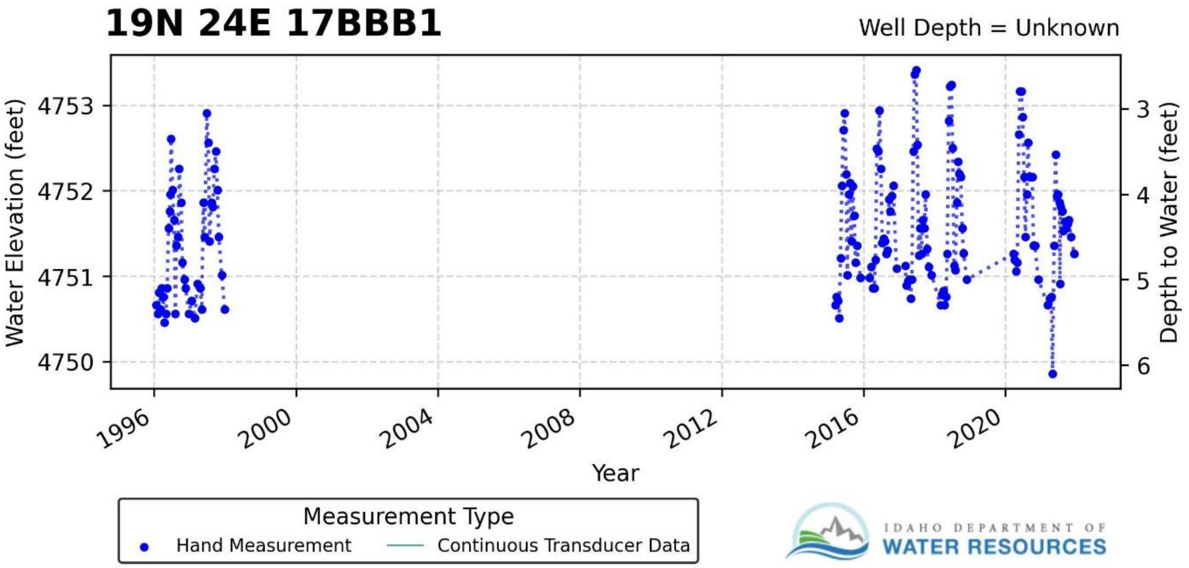

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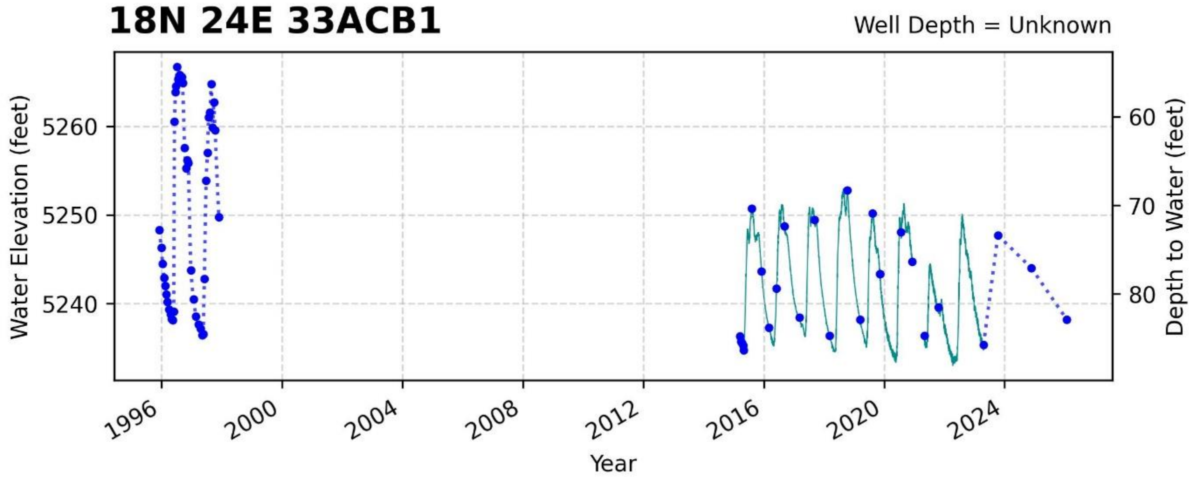
Upper Lemhi Subbasin Well Hydrographs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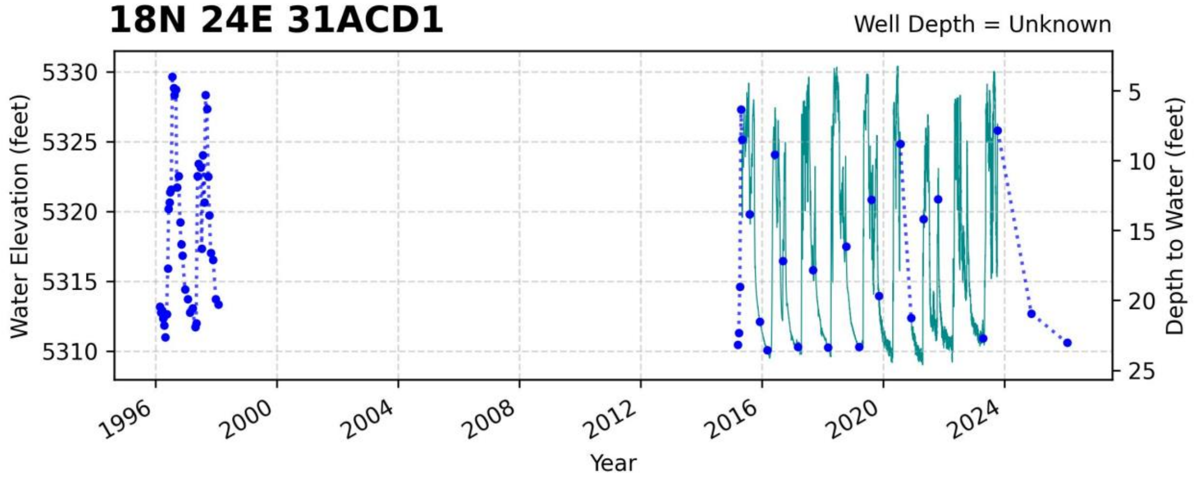
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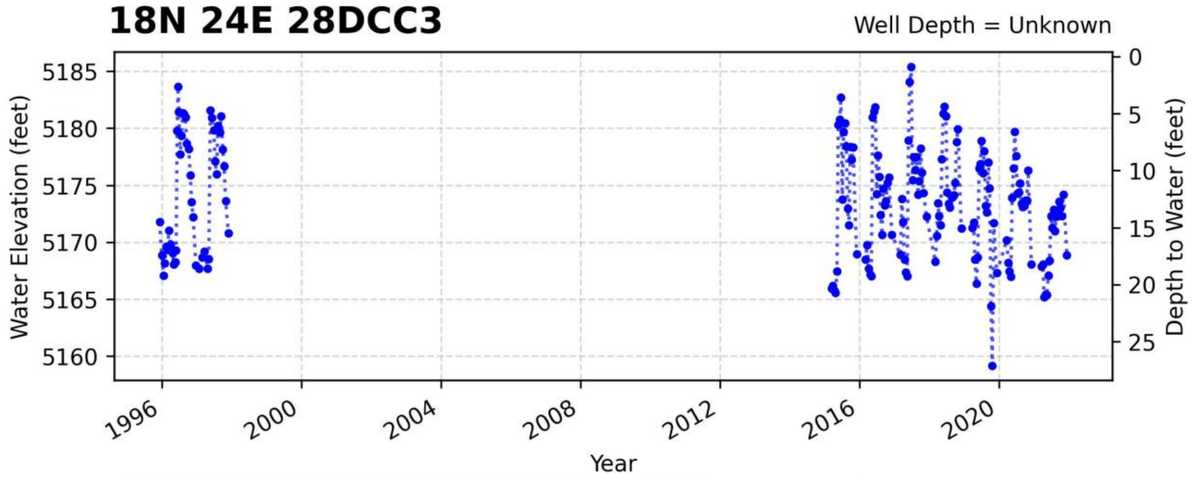
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Measurement Type

● Hand Measurement — Continuous Transducer Data

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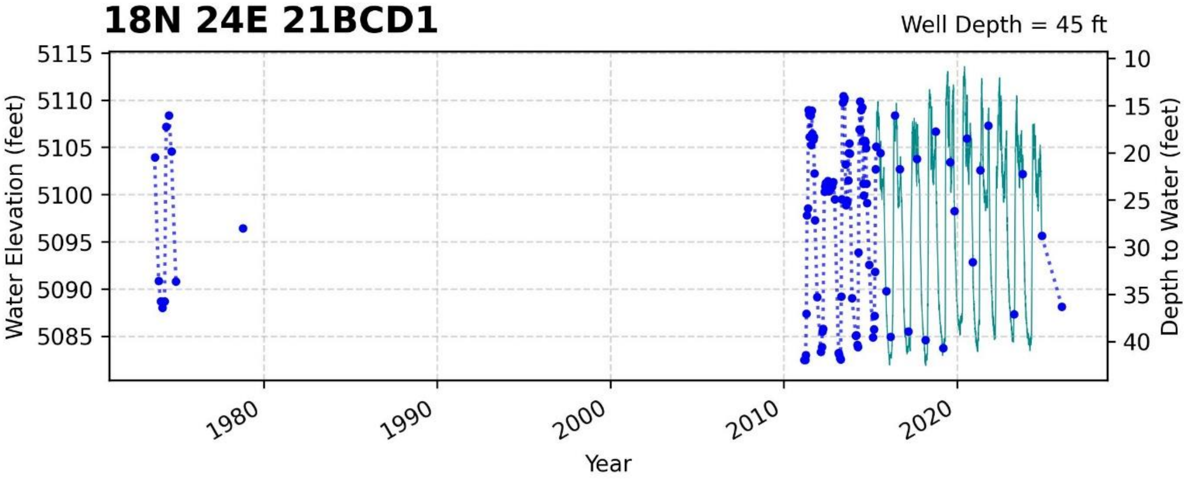
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Water Elevation (feet)
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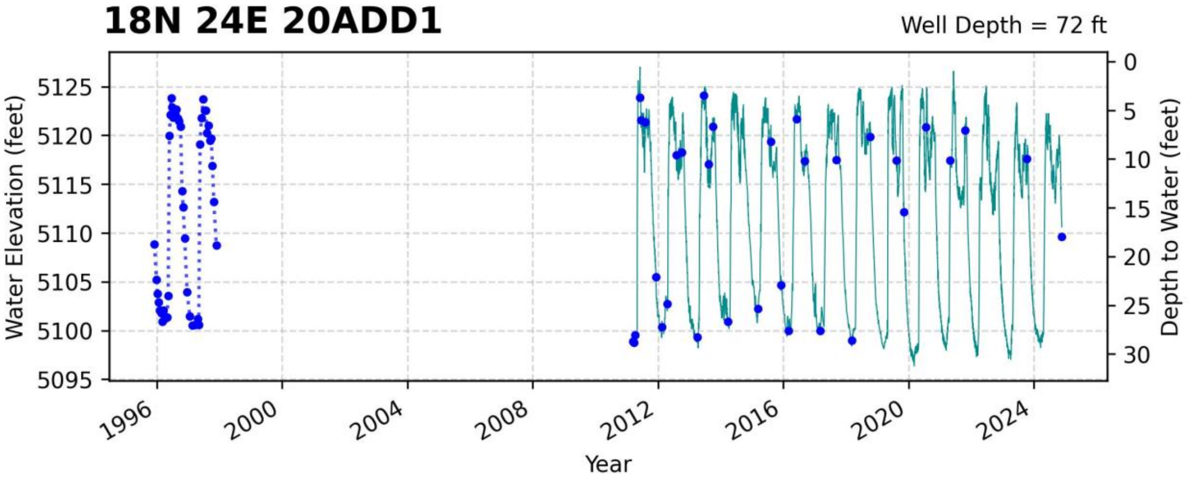
5110
5105
5100
5095
5090
5085
Depth to Water (feet)
10
15
20
25
30
35
40
1980
1990
2000
2010
2020
Year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Well Depth = 72 ft
Water Elevation (feet)
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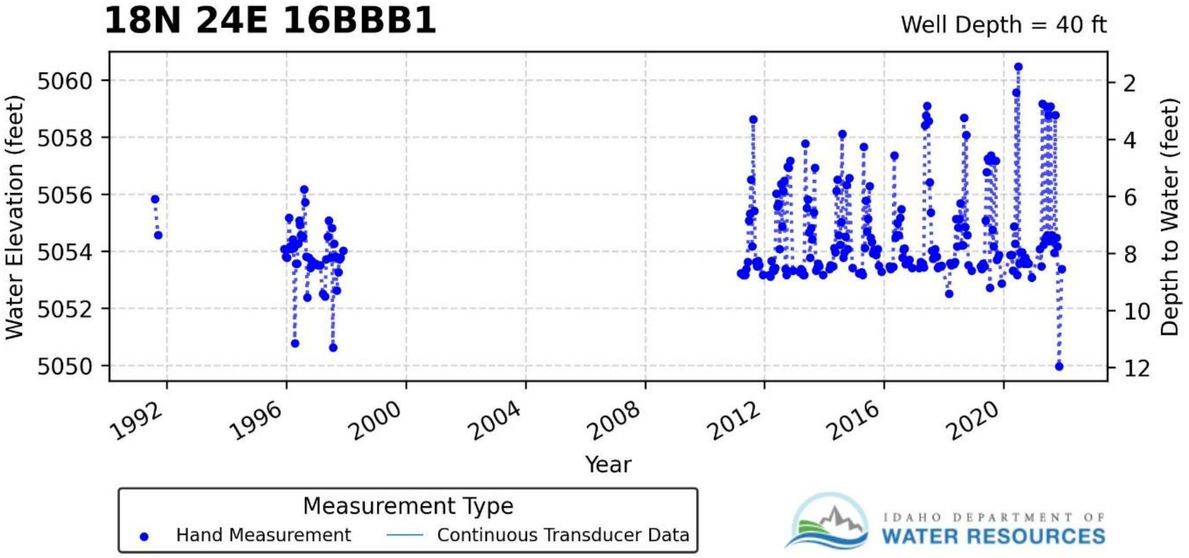
5120
5115
5110
5105
5100
5095
Depth to Water (feet)
0
5
10
15
20
25
30
1996
2000
2004
2008
2012
2016
2020
2024
Year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Well Depth = 40 ft
Water Elevation (feet)
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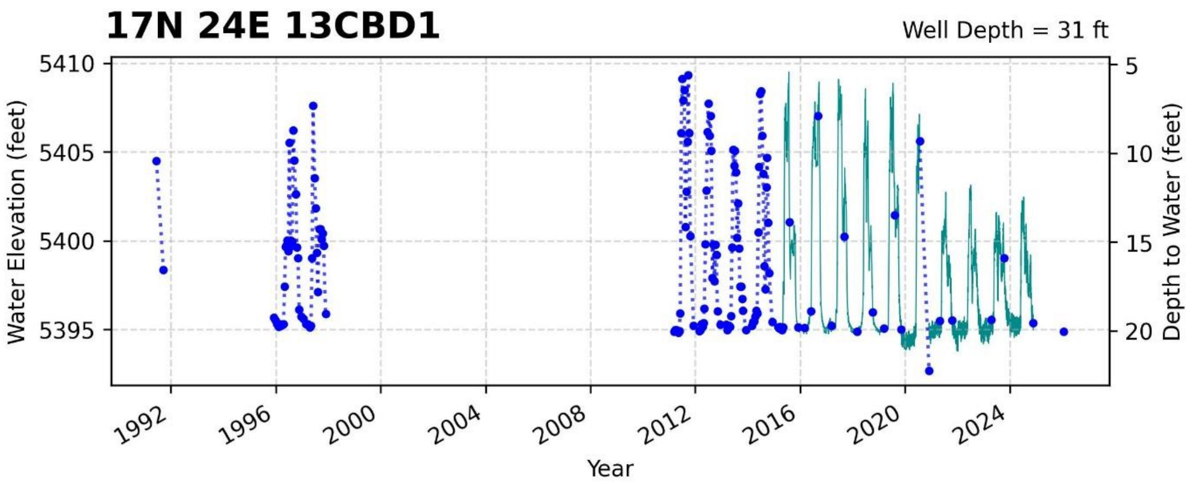
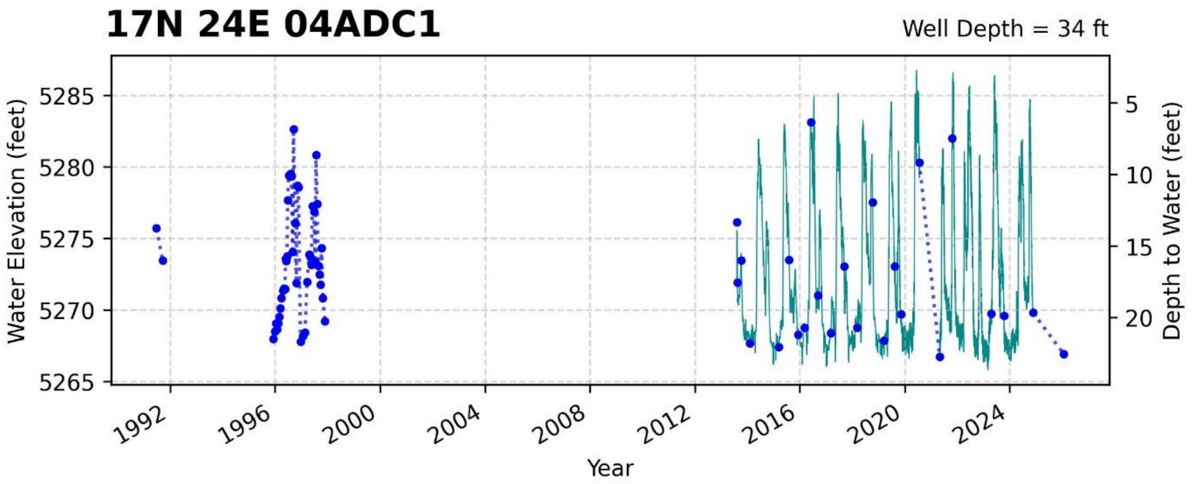
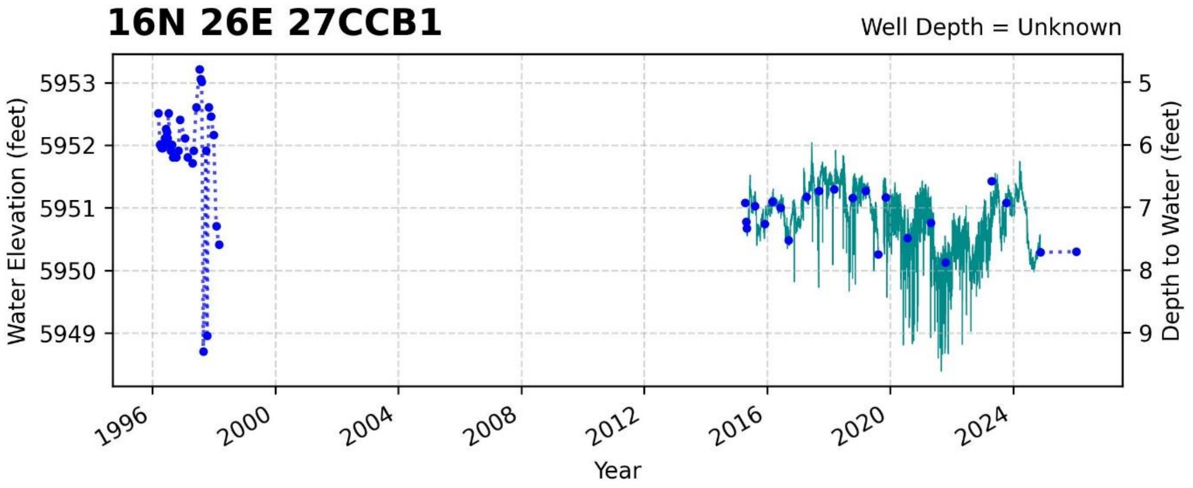
5058
5056
5054
5052
5050
Depth to Water (feet)
2
4
6
8
10
12
1992
1996
2000
2004
2008
2012
2016
2020
Year
Measurement Type
● Hand Measurement
Continuous Transducer Data

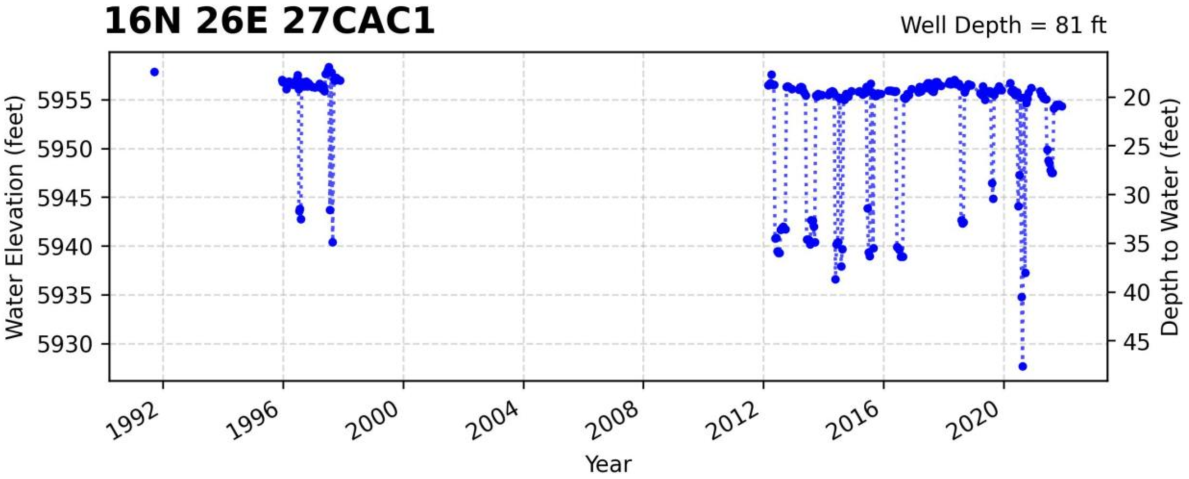


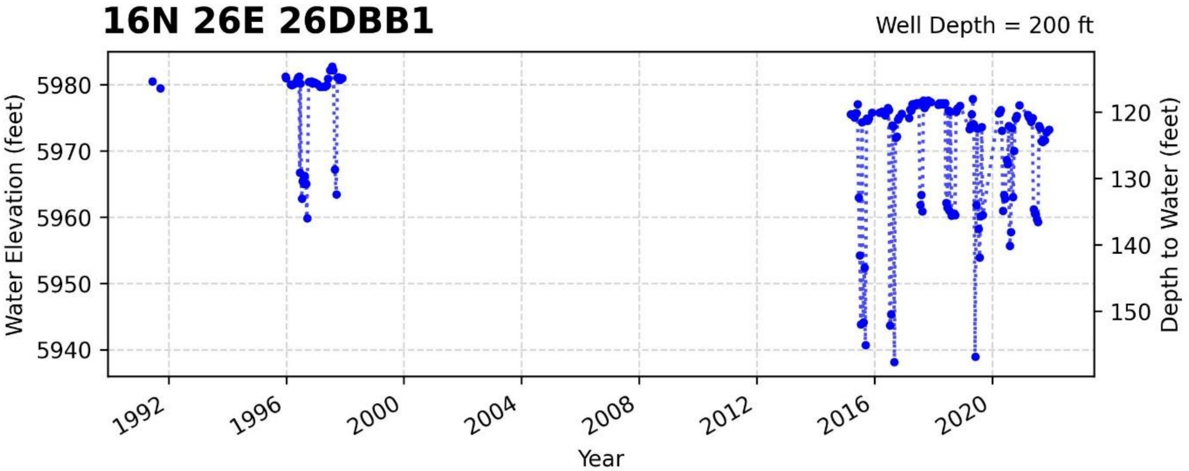


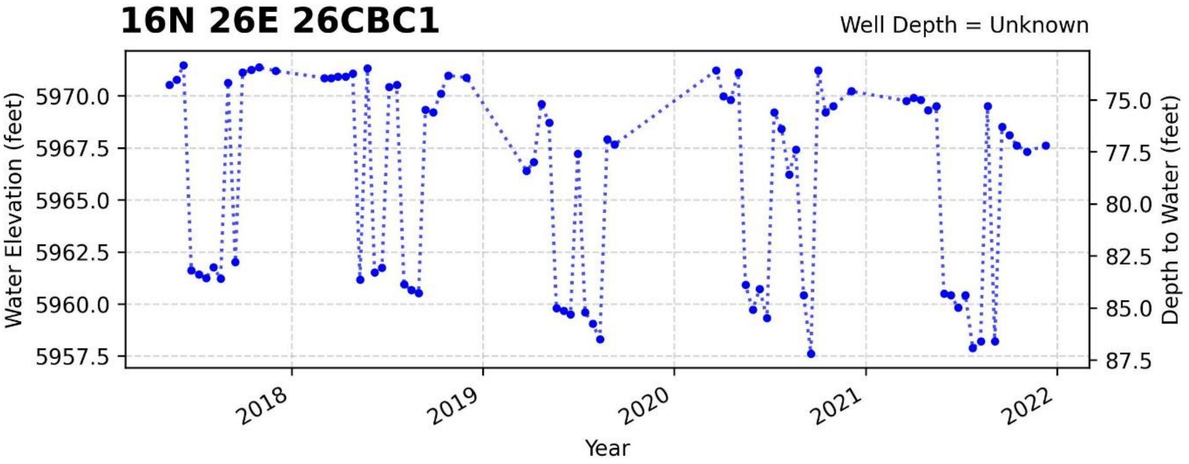


Measurement Type

● Hand Measurement — Continuous Transducer Data

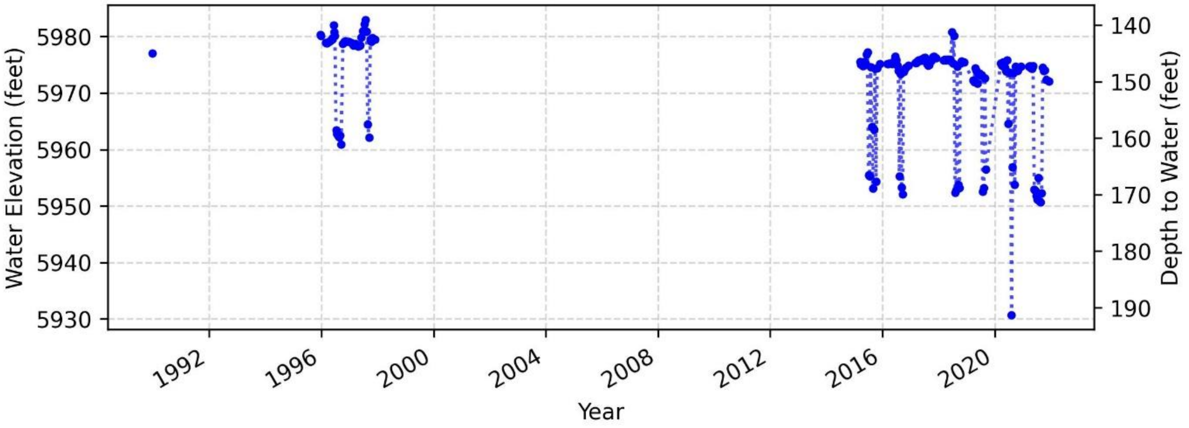

16N 26E 27CAC1
Well Depth = 81 ft
Water Elevation (feet)
Depth to Water (feet)
5955
5950
5945
5940
5935
5930
20
25
30
35
40
45
1992
1996
2000
2004
2008
2012
2016
2020
Year


16N 26E 26DBB1
Well Depth = 200 ft
Water Elevation (feet)
Depth to Water (feet)
5980
5970
5960
5950
5940
120
130
140
150
1992
1996
2000
2004
2008
2012
2016
2020
Year


16N 26E 26CBC1
Well Depth = Unknown
Water Elevation (feet)
Depth to Water (feet)
5970.0
5967.5
5965.0
5962.5
5960.0
5957.5
75.0
77.5
80.0
82.5
85.0
87.5
2018
2019
2020
2021
2022
Year
Measurement Type
● Hand Measurement
Continuous Transducer Data

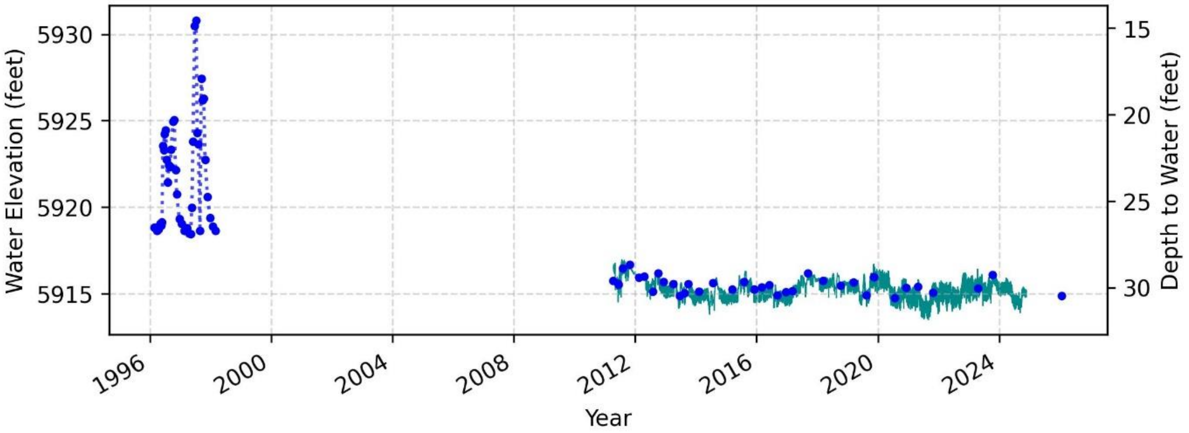
16N 26E 26ABB1

Well Depth = Unknown



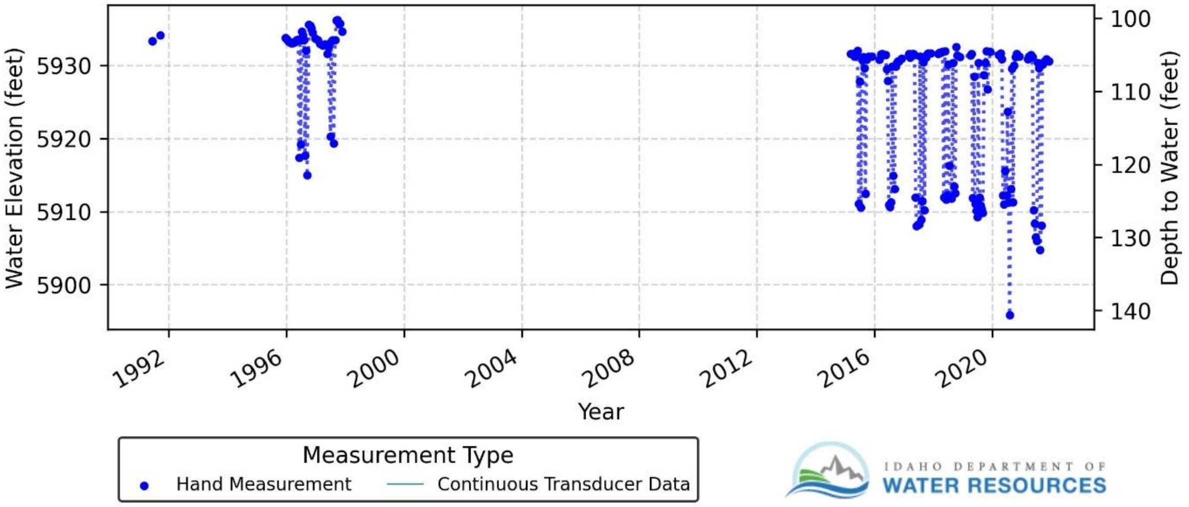
16N 26E 21CAC1

Well Depth = Unknown



16N 26E 21ACA1

Well Depth = Unknown



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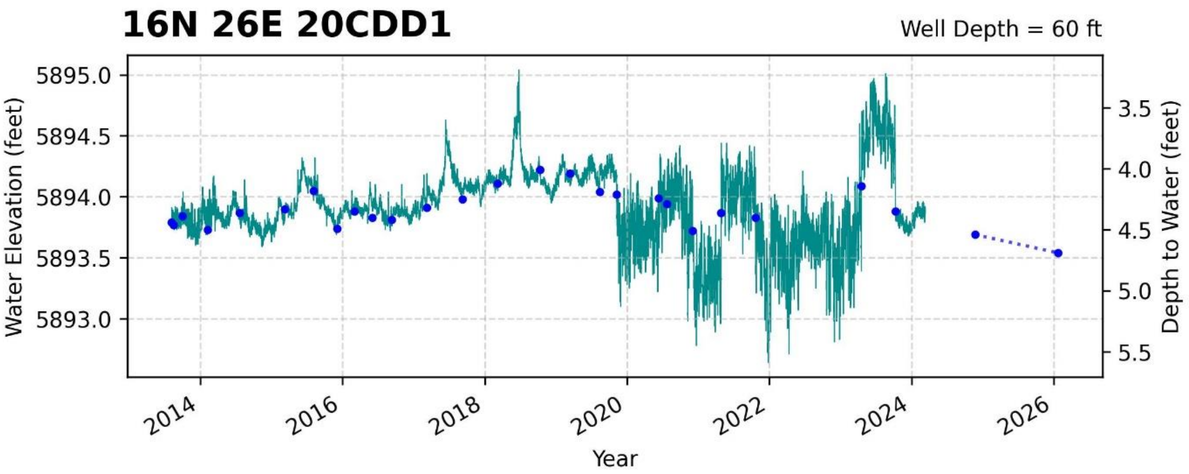
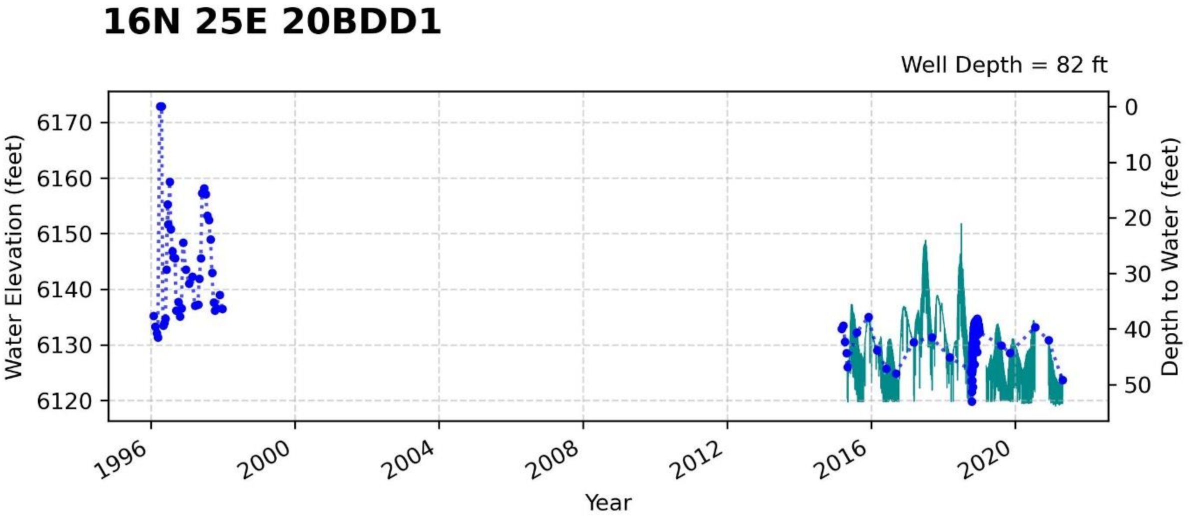
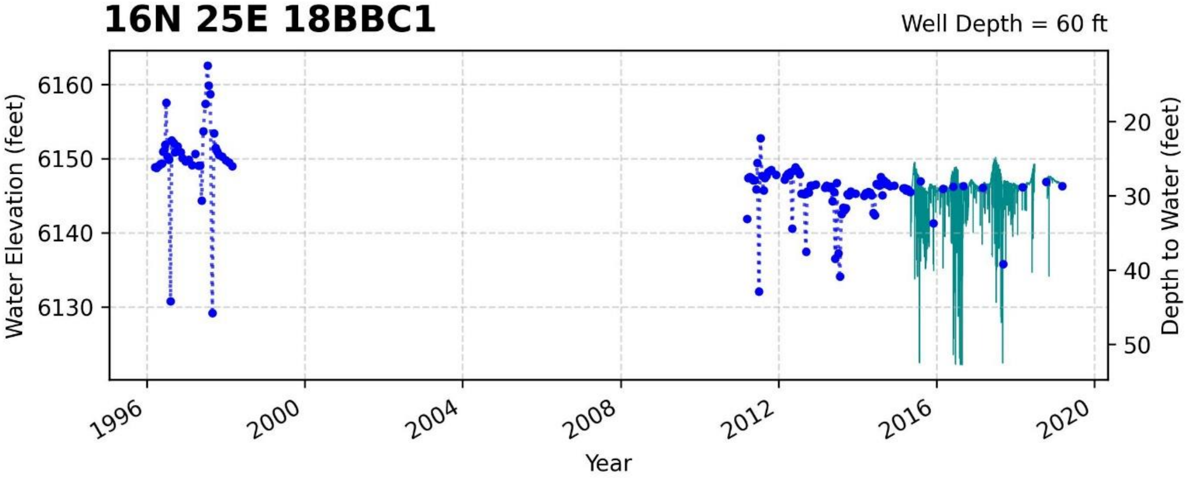


16N 26E 20CDD1



16N 25E 20BDD1



16N 25E 18BBC1

Measurement Type

● Hand Measurement — Continuous Transducer Data

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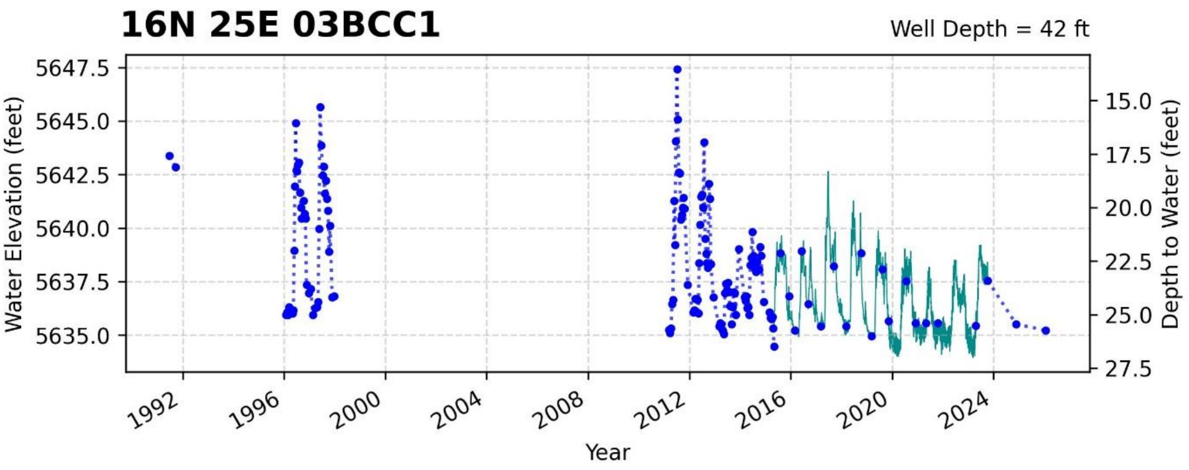

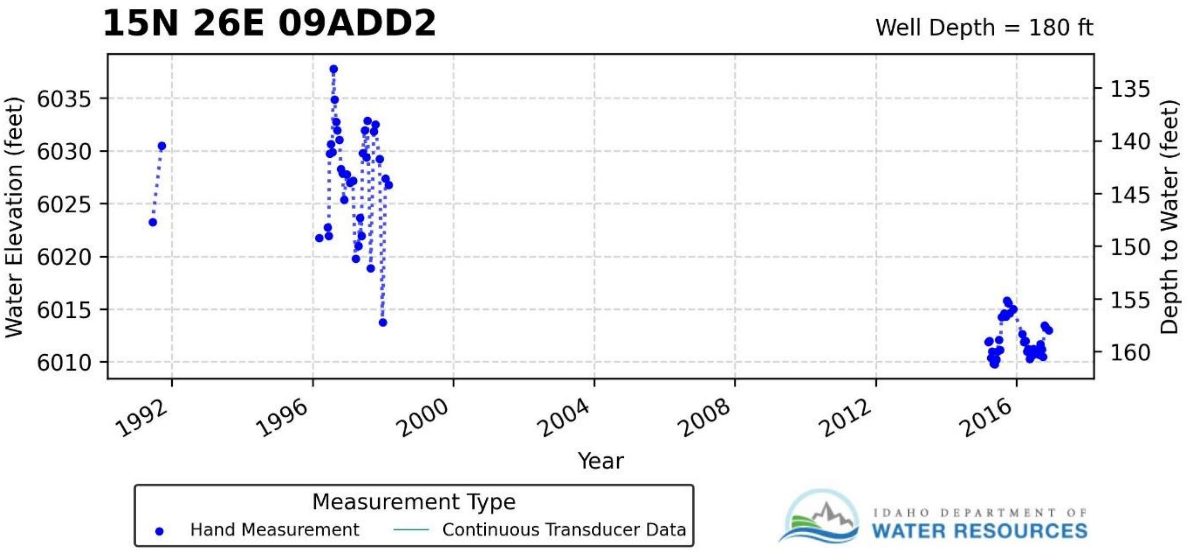

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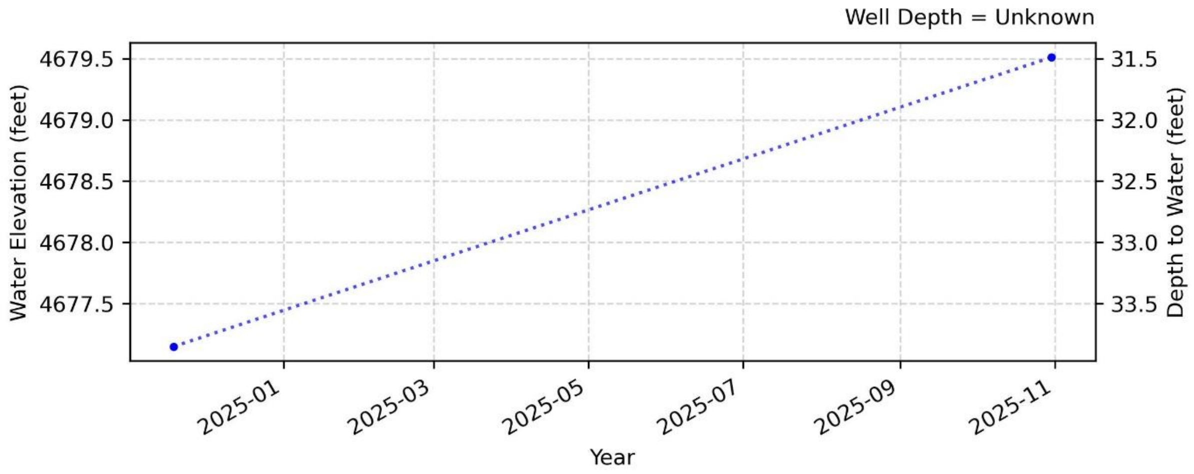
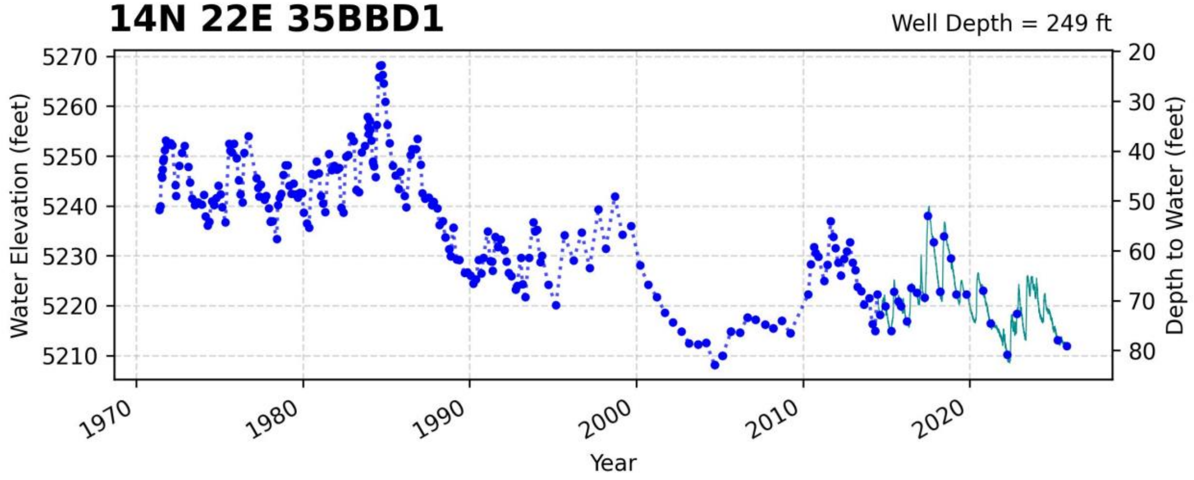
Pahsimeroi Basin Well Hydrographs

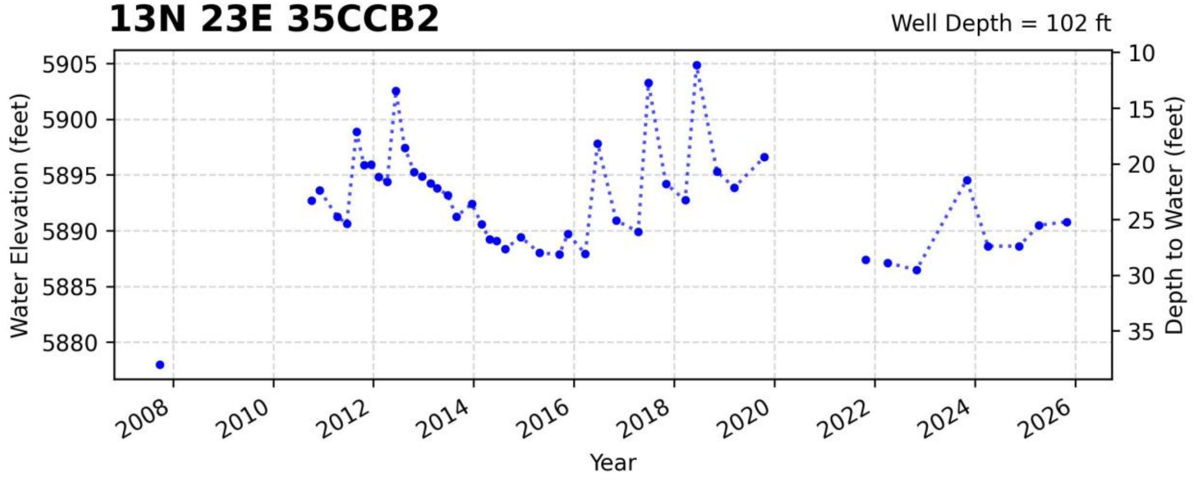
16N 20E 36CAD1

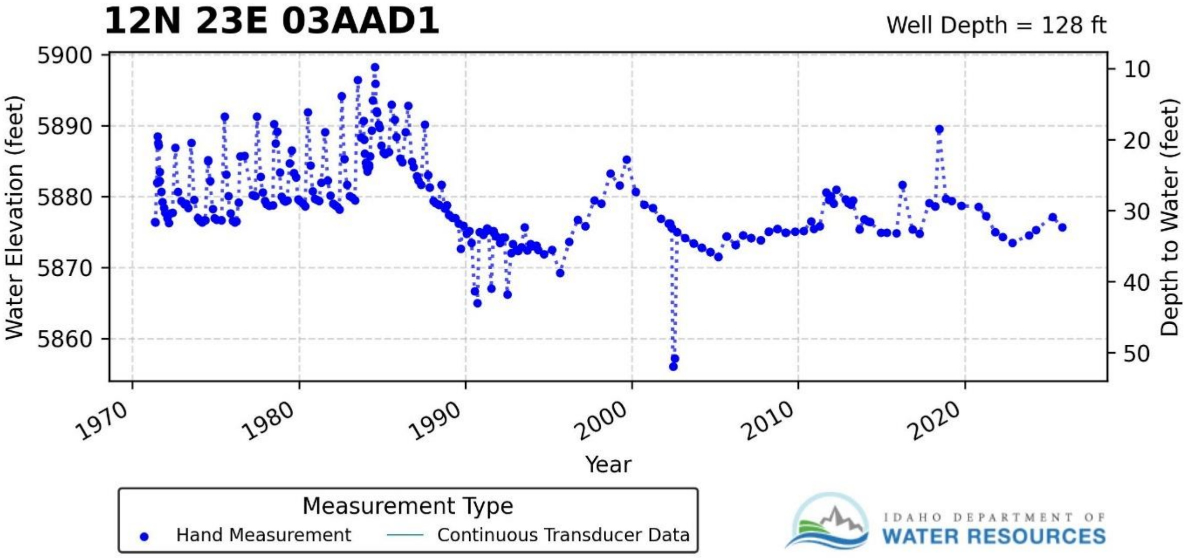


14N 22E 35BBD1



13N 23E 35CCB2




12N 23E 03AAD1
Well Depth = 128 ft
Water Elevation (feet)
5900
5890
5880
5870
5860
Depth to Water (feet)
10
20
30
40
50
1970
1980
1990
2000
2010
2020
Year
Measurement Type
● Hand Measurement
Continuous Transducer Data
IDAHO DEPARTMENT OF WATER RESOURCES

APPENDIX B

Methods: Task 11a. Trends in Streamflow

Stream Gage Selection and Data Screening

Streamflow trend analyses were conducted using the nonparametric Mann-Kendall test and Sen's slope estimator at stream gages that met minimum requirements for record length, data completeness, and data continuity. These screening criteria were applied to minimize bias associated with short-term records, incomplete seasonal coverage, or extended gaps in the period of record.

Period of Record Requirements

Trend analyses were performed only for streamflow metrics with at least ten years of qualifying annual values. The minimum data record length requirement was evaluated independently for each metric. As a result, a given gage could be included in trend analyses for some metrics and excluded for others.

Data Completeness Requirements

All streamflow metrics were derived from daily mean discharge values restricted to the April 1 through October 31 period. This period was selected to minimize the impacts of icing effects and data gaps on trend analyses.

Metric-specific data completeness thresholds were applied on an annual basis prior to calculation of annual statistics:

- Annual Mean Flow - Daily mean discharge values must be available for at least 90% of days between April 1 and October 31.
- Annual Maximum Flow - Daily mean discharge values must be available for at least 90% of days between April 1 and July 15, ensuring adequate coverage during the typical peak runoff period.
- Annual 7-Day Minimum Flow - Daily mean discharge values must be available for at least 90% of days between July 16 and October 31, ensuring adequate coverage during the typical low flow period.

Years that did not meet the data completeness thresholds were excluded from the trend analysis for that metric.

Data Continuity Requirements

Within each seasonal window (e.g., April 1 to July 15 or July 16 to October 31), years containing uninterrupted data gaps of 14 days or more were excluded. This screening measure was intended to reduce the impact of nonrepresentative annual statistics on the trend analyses.

In addition, the continuity of the period of record across years was evaluated. Stream gages with interannual gaps exceeding five consecutive years without qualifying data were considered to have insufficient record continuity for long-term trend analysis. For gages with unacceptable interannual gaps, trend analyses were conducted using the most recent continuous period of record that included at least ten years of qualifying data and satisfied all metric-specific screening criteria.

Methods: Task 11b. Trends in Groundwater Levels

Well Selection and Data Screening

Groundwater level analyses were conducted to determine long-term trends in groundwater levels, groundwater level sensitivity to drought, and trends in groundwater level seasonality. Analyses were restricted to wells that met minimum requirements for data completeness and period of record. These screening criteria were applied to minimize bias associated with incomplete annual coverage, gaps in the period of record, and data differences between instrumented and non-instrumented wells.

All groundwater level data were screened for instances of groundwater pumping. Data was excluded from analyses if there were notes documenting pumping during the measurement. In addition, all data points where the water level changed by greater than 10 feet from both the preceding and subsequent measurement, were excluded. Lastly, the dataset used for analyses was limited to the maximum daily groundwater levels for each well in an effort to remove any remaining artifacts of temporary groundwater pumping.

Data Completeness Criteria

For a year of data (at a specific well) to be included in the long-term groundwater levels analysis, there had to be at least 6 water level data points per year. The drought sensitivity analysis and one of the trends in groundwater level seasonality analyses (Table 20) were performed on only instrumented wells, which allowed for more refined data completeness criteria. For a year of data to be included in an analysis focused on instrumented wells, 90% of days within the year had to contain water level data.

A well exhibiting years where data completeness thresholds were not met did not exclude the well from the analyses unless the well did not meet the period of record requirements for inclusion.

Period of Record Requirements

For a well to be included in analyses comparing the 1995-1998 period to the 2011-2020 period, it had to have at least three years of qualifying data from 1995-1998 and eight years of qualifying data from 2011-2020. For inclusion in the groundwater level drought sensitivity analysis, the well had to have at least eight years of qualifying data from 2011-2020 and qualifying data for each year from 2021 through 2023. Trends in groundwater level seasonality were computed on all instrumented wells, and the number of years included in the analysis is documented in table 20.