FINAL

Yampa River Scorecard Project
Steamboat Segment Results and Scoring

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YAMPA RIVER SCORECARD PROJECT

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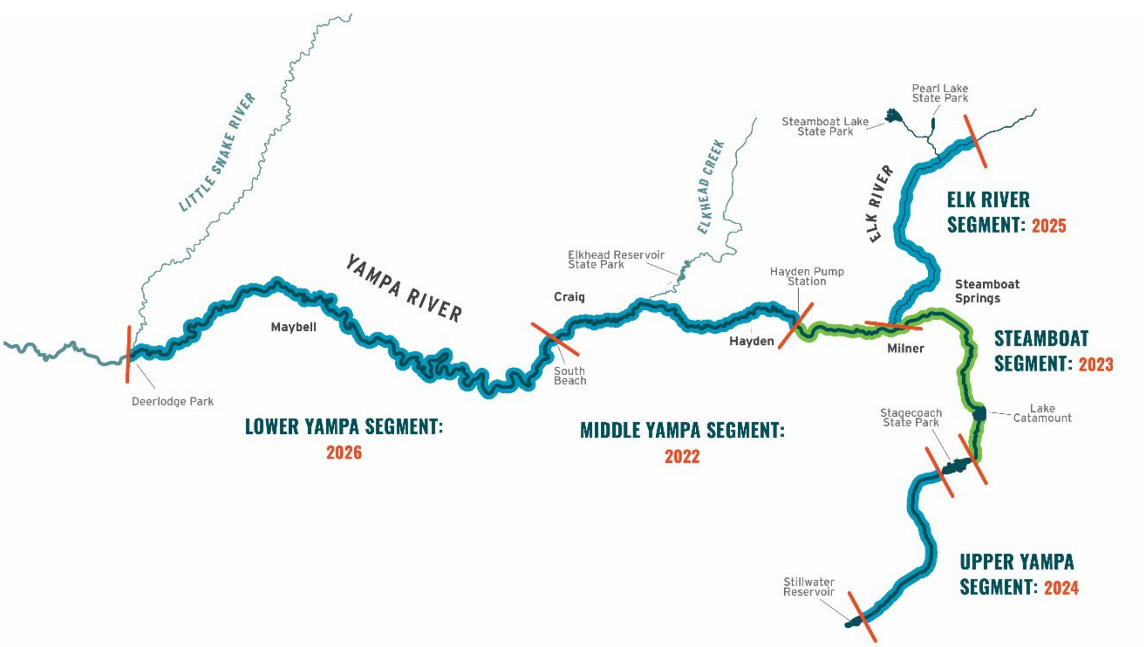
1.0 INTRODUCTION

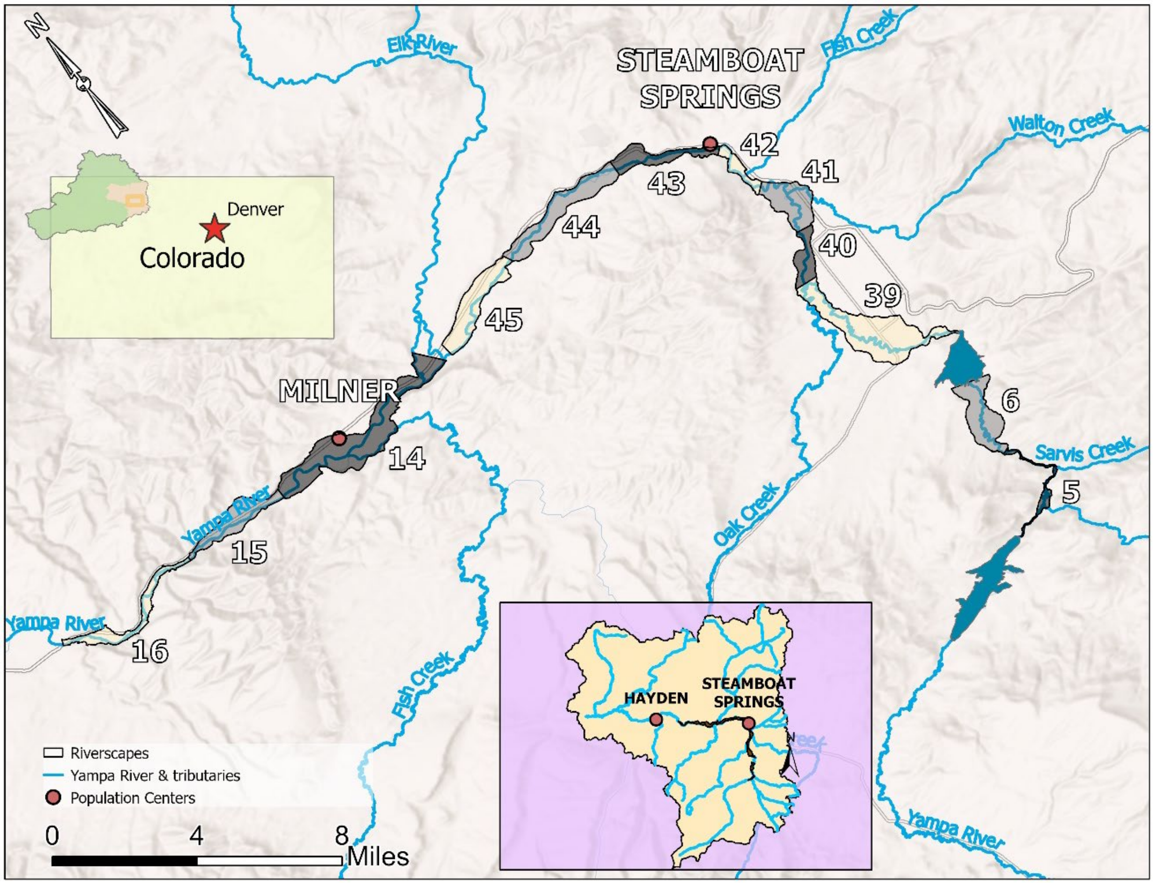
Friends of the Yampa is leading a community-based process to implement a long-term river health monitoring and evaluation program for the Yampa Basin that rates the overall condition of different segments of the Yampa River and articulates results through a *Yampa River Scorecard*. This second iteration of the Yampa River Scorecard Project (YRSP) is focused on the “Steamboat” segment of the Yampa River main stem, a 42-mile segment from Stagecoach Reservoir to the Hayden pump station. Figure 1-1 shows all five segments of the Yampa River Scorecard Project, as well as the schedule for completing assessments for each segment (Middle Yampa, 2022; Steamboat, 2023; Upper Yampa, 2024; Elk River, 2025; Lower Yampa, 2026). The Steamboat segment begins at the tailwaters of the Upper Yampa Water Conservancy District’s Stagecoach Reservoir and ends at the Xcel Pump Station (sometimes referred to as Pumphouse), a Colorado Parks and Wildlife (CPW) public river access site approximately 5 miles east of Hayden. The segment flows through the Sarvis Creek State Wildlife Area, Pleasant Valley, privately-owned Lake Catamount, CPW’s Chuck Lewis State Wildlife Area, the City of Steamboat Springs, the Elk River confluence, the unincorporated community of Milner, and a portion of The Nature Conservancy’s Yampa River Preserve. YRSP analyses do not include Stagecoach Reservoir or Lake Catamount.

Figure 1-1. Yampa River Scorecard Project Segments and Timeline



The Steamboat segment includes 12 riverscapes: 5 riverscapes identified in the Yampa Integrated Water Management Plan (IWMP) remote assessment (Yampa IWMP 2021), 5 reaches evaluated in the City of Steamboat Springs River Health Assessment portion of their Stream Management Plan (City of Steamboat Springs 2018), and two additional riverscapes that were not covered in either of these assessments but complete the geographic scope of the Steamboat segment (Figure 1-2). A score for each indicator is developed for each riverscape, and then averaged for an overall riverscape score (refer to Section 11 for more information). A weighted average across the twelve riverscapes is then calculated to generate an overall ecological health and function score for the Steamboat segment.

Figure 1-2. Yampa River Steamboat Segment Riverscapes



More information about the Yampa River Scorecard Project goals; background on determination of the five study segments and their planned timeframes; information related to the three stakeholder-identified attribute areas that are be evaluated as part of the Scorecard effort (river uses and management, people and community benefits, and ecological health and function); and details specific to the categories, indicators, monitoring methods, and scoring criteria used to assess the ecological health and function attribute area are provided in the Yampa River Scorecard Project Indicators and Methods Report (FOTY/Alba Watershed Consulting 2021). To encourage community-wide engagement and contribution to tracking river health, the monitoring and evaluation process is communicated using concise, clear, and visually appealing methods; visit https://yampascorecard.org/ for the YRSP public interface.

This document details the results and rationale behind scoring of the ecological health and function attribute area for the Scorecard's Steamboat segment. The YRSP Technical Committee agreed on a set of categories to evaluate river health and function, largely based on the Functional Assessment of Colorado Streams (FACStream, Beardsley et al. 2015), a reach-scale assessment tool developed for the US EPA and State of Colorado that rates stream health according to the degree of impairment of several ecological variables, and the Colorado Stream Health Assessment

Framework (COSHAF), a stream health assessment framework based on the FACStream variables used in many stream management plans (SMP) across Colorado, including an SMP completed by the City of Steamboat Springs covering a 12-mile section of the Yampa River through the City (City of Steamboat Springs 2018). COSHAF uses 11 variables to: evaluate the key factors that determine the health and resilience of a stream reach, ensure that all relevant aspects of stream health are considered, and serve as a guide for determining which monitoring parameters are most relevant. Other river-related report card efforts, particularly the Eco Health Report Cards undertaken by the University of Maryland Center for Environmental Science and its partners, were consulted as well. Based on these existing scorecards and ongoing input from the Technical Committee, the following categories were identified for evaluation:

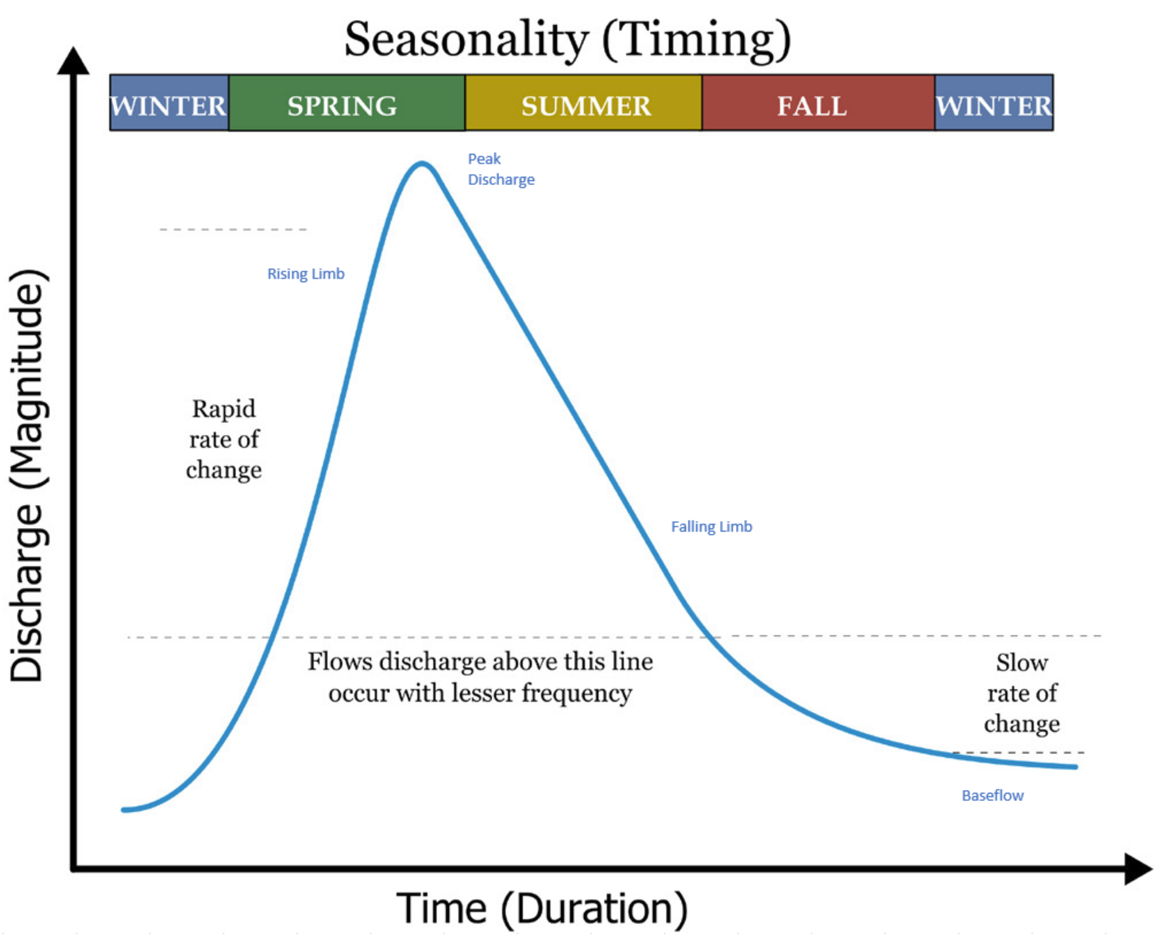
- Flow Regime (amount and timing of water supply);
- Sediment Regime (amount, timing, and type of sediment supply);
- Water Quality (physicochemical properties of water);
- Habitat Connectivity (aquatic and terrestrial habitat connectivity);
- Riverscape Connectivity (extent of riverscape/floodplain saturation or inundation);
- Riparian Condition (riparian habitat condition, including vegetation structure, diversity, and invasive species);
- River Form (channel morphology including planform, dimension, and profile);
- Structural Complexity (physical habitat including water depth, velocity, structural components, and substrate); and
- Biotic Community (community and trophic structure of the organisms in the reach).

The remainder of this document describes the suite of categories and indicators that, when evaluated, provide a comprehensive understanding of river health and function across the Steamboat segment. Each sub-section discusses one of the nine categories listed above, with further subdivisions by indicator. The discussion of each indicator contains a description of the indicator, the data sources and methods used to evaluate the indicator, the scoring criteria that are applied, the results and rationale for scoring, and associated scores. Existing data are used to the extent possible, supplemented by additional data analysis and field data collection where specified.

2.0 FLOW REGIME

Flow regime is defined as the characteristic pattern by which water is supplied to a river segment from its contributing watershed. It is often represented by a hydrograph, and is dictated by precipitation, inter- and intra-annual weather patterns, watershed characteristics, and human influences. Flow regime is a primary determinant of a river's structure and function. In particular, the magnitude, duration, frequency, and timing of river flow interact with the landscape to determine the functions that the river performs. The Yampa River Scorecard evaluates two indicators within the flow regime category: the overall **hydrograph** and the annual **snowpack**. Figure 2-1 provides a schematic diagram of an annual hydrograph, illustrating important concepts such as peak discharge, base flow, and rising and falling limbs. The final flow regime score is calculated as 90% hydrograph indicator score and 10% snowpack indicator score. The Technical Committee decided on this uneven split to avoid double counting and consider the fact that snowpack is a driver of flow regime and exerts a major influence on the elements of the hydrograph indicator.

Figure 2-1. Hydrograph Schematic Diagram



2.1 HYDROGRAPH INDICATOR

The hydrograph indicator considers the following components of the Yampa River's flow regime:

- Magnitude, timing, and duration of **peak flows**. Adequate peak flows are essential to river health and function. In particular, the magnitude of a high flow event controls how much of the floodplain is inundated, and for how long, and is therefore of substantial importance for maintaining riparian vegetation health, distributing sediment through and across the river corridor, building structural complexity, and enabling connectivity between in-channel and floodplain habitat. Snowmelt-driven peak flows during spring runoff are also important for numerous watershed services, such as fishery support, riparian habitat quality, sediment flushing, water quality maintenance, recreation, aesthetics, and groundwater connection and recharge.

- Magnitude, timing, and duration of **base flows**. Base flows are the low flows that occur after snowpack melt, during the dry season, usually from late summer to early spring. They provide critical support of aquatic habitat and riparian connectivity when the stream needs it most after peak flows have receded. Low flows help to maintain essential aquatic habitat, riparian vegetation, and a healthy fishery, and also influence water quality and sediment transport. Sources of base flows are rainfall events and slowly percolating groundwater, and they can be augmented by reservoir releases and irrigation return flows in managed systems.

- **Total annual flow volume**, or the amount of water delivered to the riverscape from its contributing watershed, is an important overall metric describing flow regime in the Yampa River basin both from a human use perspective and as it relates to water delivery across the riverscapes.

- Magnitude and variability of **flow rates of change**, or the rate at which flow changes (for example, how quickly flows rise during spring snowmelt), are important for various ecological aspects of the river, including habitat connectivity, aquatic habitat, riparian condition (particularly seedling establishment), and sediment transport. The speed at which flows change can be driven by rainfall, snowmelt, dam releases, diversion operations, and various other natural dynamics and human actions. Though there are some differences in their ecological and physical importance, here we evaluate both rising and falling rates together as one by considering the overall average change from natural to current conditions.

This analysis also considers timing of peak flow, which can be used as a proxy for changing climatic conditions that impact streamflow. Together, the various sub-indicators are given the following weights to determine a total score for the hydrograph indicator: 30% peak annual flow, 30% annual 7-day minimum flow, 20% annual flow volume, 15% flow rate of change, and 5% peak flow timing.

2.1.1 Data Sources and Evaluation Methods

Development of scores for this indicator relies heavily on existing USGS stream gauge data, modeled natural and existing streamflows, and local knowledge. As a holistic indicator, this variable uses expert judgement and review and analysis of available data to generate a single score for the hydrograph indicator. The rationale behind that score is heavily influenced by the peak flow and base flow components of the hydrograph discussed in the previous section.

The stream gauges within the Steamboat segment of the Yampa River are as follows:

(1) USGS 09237500 YAMPA RIVER BELOW STAGECOACH RESERVOIR, CO – This is an active USGS gauge located just below Stagecoach Dam (1943-2023).

(2) CO DWR YAMPA RIVER ABOVE LAKE CATAMOUNT NR STEAMBOAT SPRINGS (YAMABVCO) – This is an active gauge operated and maintained by CO DWR located just upstream of Lake Catamount (2000-2023).

(3) USGS 09239500 YAMPA RIVER AT STEAMBOAT SPRINGS, CO – This USGS gauge is located near the 5th street bridge in the town of Steamboat Springs, CO (1989-2023).

(4) USGS 09240020 YAMPA RIVER BELOW SODA CREEK AT STEAMBOAT SPGS, CO – This USGS gauge is located below the confluence with Soda Creek and is operated seasonally from May-October (2008-2023).

The Wilson Water Group (WWG) conducted hydrology modeling for the Basin Implementation Plan Phase 3 (WWG 2018), where these and other stream gauge nodes within the Yampa Basin were used to explore the potential benefits and impacts of Yampa-White-Green Basin Roundtable projects under different hydrologic scenarios, including natural streamflows, baseline streamflows, and future scenario streamflows. The modeled natural flow regime is derived by removing the influence of human activities from current recorded streamflow to estimate natural, undisturbed flows at locations on the Yampa River. Disturbance activities that can be accounted for include diversions, irrigated agriculture and return flows, storage and releases, and water rights administration. Existing streamflow conditions, referred to as baseline conditions, represent recorded diversions, current consumptive demands, administration, instream flow and recreational in-channel diversions (RICD), existing infrastructure, and reservoir operations, and include modifications based on water-user interviews. While the WWG modeling did not include pre-measurement changes to hydrology or paleohydrology in establishing “natural” streamflows, the authors of this report acknowledge the relative recency of the USGS and CO DWR stream gauge data.

The Yampa IWMP remote assessment’s Data Synthesis Report (Yampa IWMP 2021) applied these data to percent departure of baseline conditions from natural conditions for two metrics: (1) percent departure of high flows and (2) percent departure of low flows. The two metrics were used in the remote assessment to provide a high-level, holistic indication of flow regime alteration within the Yampa basin. However, a more detailed hydrologic analysis of more than 107 metrics is presented in the Yampa River Hydrologic Review and Needs Assessment Report (Lotic 2021) and associated interactive online storyboard application (Mason 2021). Additional metrics from this report and an associated storyboard are changes in annual flow volume and rise and fall rates of the hydrograph from natural to human-altered conditions.

To rate the hydrograph indicator, streamflow data from the four gauges listed above, as well as additional streamflow nodes within the 42-mile Steamboat segment that are used in the detailed hydrologic analysis (Lotic 2021, Mason 2021), were used to determine the departure of existing flow regime from modeled natural flow conditions, as well as to compare the baseline (existing) hydrograph to the modeled natural hydrograph over the period of record. In particular, daily flow data for modeled baseline (modeled existing) and modeled natural flows for all gauges/nodes covering the years 1975-2013 are compared. Riverscapes that lack modeling nodes are assumed to score similarly to the riverscape immediately upstream for metric(s) calculated solely from model data, except where significant withdrawals and/or tributaries exist within the riverscape that lacks nodes. Future iterations of the Yampa River Scorecard Project will explore acquiring similar modeled data that extends to more recent years (i.e., beyond 2013).

Additional data sources used to augment this review of historical modeled hydrographs are current local knowledge of dry-up points or significantly reduced flow locations that are not reflected in the existing stream gauge records, as well as a recent USGS publication investigating streamflow and water quality in the upper Yampa River Basin from 1992-2018 (Day 2021). This publication also conducts a streamflow trend analysis on the main stem Yampa River over a much longer time period (since 1910).

2.1.2 Scoring Criteria

The descriptive and semi-quantitative scoring criteria outlined in Table 2-1 are used to rate the hydrograph indicator. Each sub-indicator (e.g., 1-day maximum flow) is given a score and then sub-indicator scores are compiled to yield an overall score.

Table 2-1. Hydrograph Indicator Scoring Criteria

Grade	Description
A	Baseline hydrograph characteristics resemble the natural hydrograph. Magnitude and duration of annual discharge peaks and base flows closely resemble natural hydrograph. Percent of natural median 1-day maximum and 7-day minimum discharge estimated to be greater than or equal to 90% and lack of observable temporal downward trends in the gauge record exists. Net percent of natural flow greater than 90% of the total annual volume. Flow rates of change closely resemble natural hydrograph; average rise and fall rates greater than 90% of natural rates.
B	Hydrograph has a near natural seasonal pattern, but peaks are attenuated, elevated, extended, or shortened, with 75-90% of natural median 1-day maximum flow magnitude. Seasonal 7-day minimum discharge approximately 75-90% of natural flow. One-day maximum and 7-day minimum flows lack statistically significant downward trends over time, though some observable trends may be present. Net percent of natural flow between 80-90% of total annual volume. Rate of change for flows are 80-90% of natural rates.
C	Hydrograph has a natural seasonal pattern, but peaks are attenuated, elevated, extended, or shortened, with 50-75% of natural median 1-day maximum flow magnitude. Periods of biologically critical low flows occur occasionally, and seasonal 7-day minimum discharge is approximately 50-75% of natural flow. One-day maximum and 7-day minimum flows display statistically significant downward trends for a given time period (e.g., April flows) but not at the overall annual scale. Net percent of natural flow between 65-80% of total annual volume. Rate of change for flows are 60-80% of natural rates.

D	Disrupted seasonal hydrograph patterns and/or similarity to natural median 1-day maximum flow magnitude less than approximately 50%. Periods of biologically critical low flows are frequent, with less than 50% of natural seasonal 7-day minimum discharge. One-day maximum and 7-day minimum flows display statistically significant downward trends for several given time periods (e.g., spring month flows) but not at the overall annual scale. Net change percent of natural flow between 50-65% of the total annual volume. Rates of change for flows are 50-60% of natural rates.
F	Disrupted seasonal hydrograph patterns and/or similarity to natural median 1-day maximum flow magnitude substantially less than approximately 50%. Frequent and extended periods of biologically critical low flows and/or periods of no flow occur, with less than 50% of natural seasonal 7-day minimum discharge. One-day maximum and 7-day minimum flows display statistically significant downward trends for a majority of given time periods (e.g., all but winter flows) and at the overall annual scale. Net percent of natural flow less than 50% of total annual flow volume. Rates of change for flows are less than 50% of natural rates.

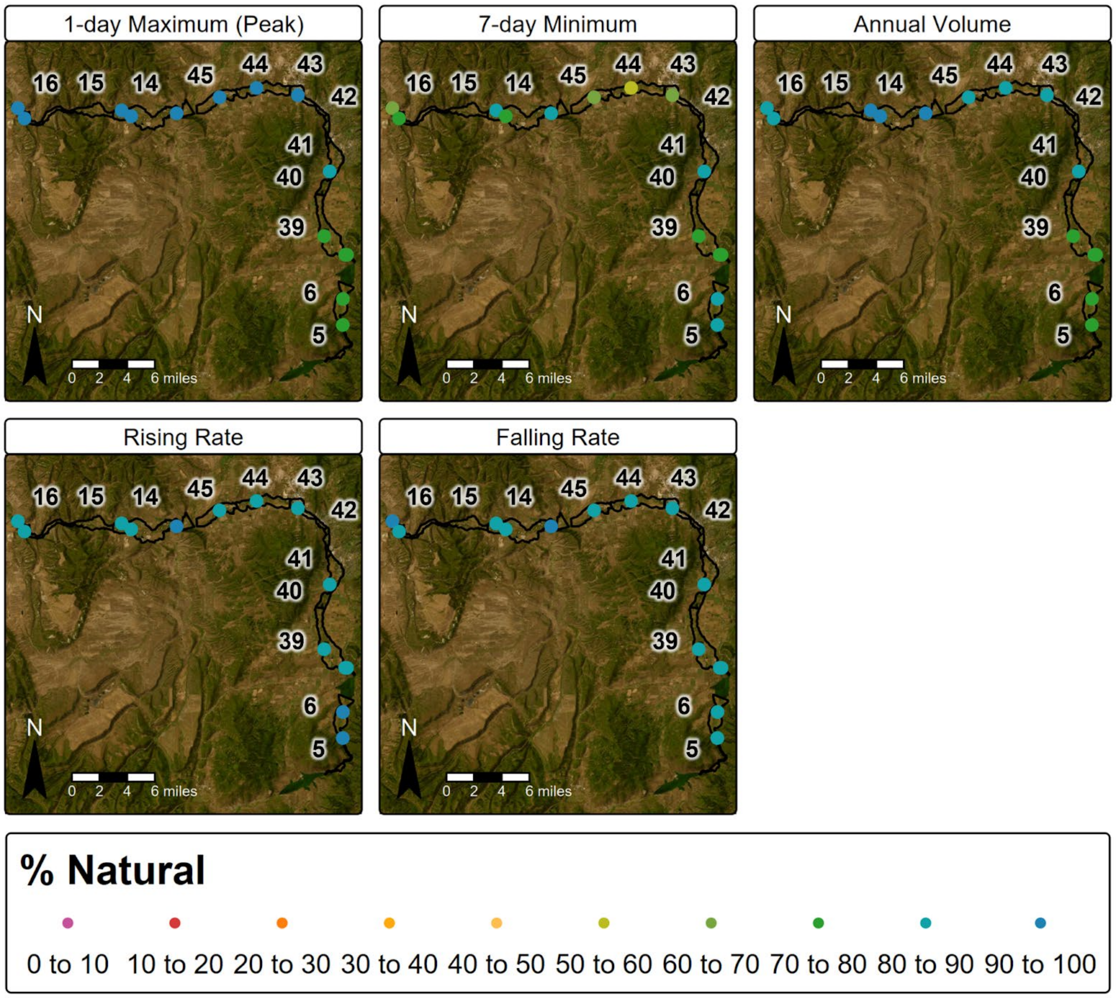
2.1.3 Results

Results and findings of previous reports regarding the health of the hydrologic regime on the Yampa River (Wilson Water Group 2018, Lotic 2021, Mason 2021) have been refined and synthesized to integrate into the Scorecard framework. Analysis focuses primarily on peak flows, minimum flows, total flow volume, and rates of flow rise and fall, as these correspond strongly with natural function. Additional consideration is given to the timing of peak flows.

Percent of natural in median annual 1-day maximum flows is a metric that reflects the degree to which the magnitude of high flow events has changed during the period of record studied (1975-2013, Yampa IWMP 2021). In many riverscapes (43-45; 14-16), the modeled baseline 1-day maximum flow is similar to natural (>90+). Similarities to natural flows are less pronounced for the more upstream riverscapes, with riverscapes 5, 6, 39, and 40 having modeled peak flows approximately 78-79% of modeled natural flows. Riverscapes 41 and 42 have flows roughly a midpoint between the more altered upstream riverscapes and the more natural downstream ones; here, modeled peak flows are 83% of natural flows. Though no modeling results are reported for riverscapes 15, 40, and 42 due to the lack of modeling nodes (i.e., the points of the river at which flows are simulated) in these riverscapes in our data sources (Mason 2021, Lotic 2021), flow metrics in these riverscapes are assumed to be relatively identical to those of the immediately upstream riverscape when no observable significant additions or withdrawals from flow are present (riverscape 15). For riverscapes that lack nodes and in which substantial tributaries enter – riverscape 40, where Oak Creek enters at the extreme upstream end, and riverscape 42, where Fish Creek enters roughly halfway between the upstream and downstream boundaries of the riverscape – node locations in the downstream riverscape were examined to see if modeling results could be responsibly transferred. For riverscape 40, a modeling is node is located just downstream of the boundary between riverscape 40 and 41; results from this node are thus illustrative of flow conditions in riverscape 40 as well. For riverscape 42, Fish Creek enters halfway through and likely alters flow dynamics substantially; because of this, the conservative approach was taken and flow metrics were assumed to be the same as upstream riverscape 41. In general, changes to peak flows are more pronounced in the riverscapes upstream of the City of

Steamboat Springs, where scores range from B to B-, and less substantial downstream, where scores are in the A to A- range (Table 2-2).

Figure 2-2. Percent of Natural Flow Characteristics for Hydrograph Sub-Indicators at Steamboat Segment Modeling Nodes



At USGS 09239500 (Yampa River at Steamboat Springs, CO located in riverscape 42), between 1992 and 2018, 1-day maximum flows have fluctuated showing neither consistent upward or downward trends, except for a significant downward trend in the months of January and February (Day 2021). At USGS 09237500 (Yampa River below Stagecoach Reservoir, CO) a similarly observable significant downward trend is seen from September to February. At both stations, it is likely that the downward trends are driven by reservoir operations at Stagecoach Reservoir (e.g., storage of winter and spring runoff), land-use (e.g., irrigation trends), and climate-related alterations (e.g., changes in snowpack) that have impacted streamflow basin-wide (Day 2021). Data from USGS 09242500 (Elk River near Milner, CO) and USGS 09238900 (Fish Creek at Upper Station near Steamboat Springs, CO), which contribute to the Yampa at riverscapes 14 and 42, respectively, show 1-day maximum flows that have insignificant fluctuating trends. Inspection of data from the gauge above Lake Catamount operated by CO DWR confirms that peak flow follows a similar pattern to peak flow at USGS 09237500, but was not included in the Day report trend analysis which is used to score this indicator. Overall, while many of the above discussed trends are not statistically significant on an annual basis, the observable downward direction suggests that flows during these months may continue to decline in the future.

The metric assessing the percent of natural for median annual 7-day minimum flow quantifies the extent to which low flows have deviated from their natural conditions. Similarity of 7-day minimum flows to their natural state is relatively greater in riverscapes 5 and 6 downstream of Stagecoach Reservoir, where they are with 81% and 82% of natural, respectively, and in the more downstream riverscapes 41 and 42 (85% of natural). However, riverscapes 39 and 40 show a more substantial departure from modeled natural conditions, with similarities of 73%. Riverscapes 43-45 show even higher departures from modeled natural conditions, with minimum flows of 63%, 56%, and 63% of natural, respectively. Venturing downstream of Steamboat Springs, riverscapes 14 and 15 exhibit relatively higher similarities to natural flows (81%), while riverscape 16 exhibits a similarly high departure to riverscapes 43-45 (67% of natural) (Yampa IWMP 2021, Lotic 2021). It is worth noting that while these variations from the baseline (existing) flow to the natural flow conditions are indeed significant, they fall within a relatively low magnitude of potential ecological risk, as indicated by Lotic (2021).

When examining the recorded stream gauge data at USGS 09237500, a notable pattern emerges in the 7-day minimum flows measured during the years 1992-2018. Significant downward trends are observed at the monthly scale, particularly from September to February, and a clear downward trend at the annual scale (Day 2021). Again, although not included in the analysis used to score this indicator, inspection data from the period of record for the CO DWR gauge above Lake Catamount confirms that annual low flows follow a similar pattern to those of USGS 09237500. It is important to note that this location is situated below Morrison and Sarvis Creeks, which add considerable flow, thereby increasing the contributing area significantly. However, this additional contribution does not diminish the significance of the observed trend, indicating that the downward pattern in flows is a robust finding that persists even when considering these additional sources. USGS 09237450 (Yampa River above Stagecoach Reservoir, CO) exhibits a significant annual downward trend for this same metric. Similarly, at USGS 09239500, downward trends are observed at the annual scale, with noteworthy significance during the months of January and February. In contrast, USGS gauge 09238900 indicates significant upward trends for the late summer and early fall months, spanning August to October, contributing to an overall significant annual upward trend. This trend extends downstream to the confluence with Fish Creek. However, USGS 09242500 displays little to no observable trends. While some months and several annual analyses for all gauges exhibit variability or lack statistical significance, the prevalence of annual trends in the downward direction suggests a potential continued decline in flows in the future (Day 2021). Overall, analysis suggests that baseflows are observably altered from natural, and riverscape scores for baseflow are generally lower than peak flows (spanning a range from B to C). Riverscape scores for the baseflow component of the hydrograph indicator are presented in Table 2-2.

The streamflow data recorded at USGS gauge 09237500 shows noteworthy patterns during the years 1992-2018, specifically between September and February. These patterns indicate significant downward trends in all three key metrics: the annual 1-day maximum, mean flow, and 7-day minimum (Day 2021). These findings align with the conclusions drawn from the Yampa IWMP and are likely influenced by multiple factors, as mentioned previously. One contributing factor to these observed trends is the flow of water entering Stagecoach Reservoir. These downward trends may, in part, be attributed to changes in streamflow patterns both upstream and downstream of the reservoir. The management of flow through the reservoir, especially in response to peak-season runoff and low-flow season augmentation, plays a crucial role in shaping these trends. Examining USGS 09237450, located outside of the primary focal segment, the analysis reveals that trends in 1-day maximum flows are inconclusive. Nevertheless, the data shows significant downward trends in streamflow during the winter months, particularly in mean flow and 7-day minimum statistics. This observation underscores the interconnected nature of the streamflow patterns both above and below the reservoir. It is important to acknowledge that certain limitations associated with the modeling approach, and potential data gaps may contribute to the relatively high departures observed below Stagecoach Reservoir (Day 2021, Lotic 2021).

Modeling of total flow shows that flow volumes in the more upstream riverscapes of 5, 6, 39 and 40, which are below Stagecoach Reservoir (5, 6) and immediately downstream of Lake Catamount (39, 40), have flow volumes relatively somewhat more diminished from natural conditions (approximately 75% of modeled natural flows). Beginning around riverscape 41, where Oak Creek enters the mainstem Yampa River, flow volumes begin to more resemble natural (83%) and increase consistently in the downstream direction (from approximately 85% of natural in riverscapes 43-45 to roughly 90% of from natural in riverscapes 14-16). Scores reflect this general spatial pattern, ranging from B- in the upstream-most riverscapes to A-/B+ in the downstream most (Table 2-2).

Finally, for flow rates of change, which are indicative of the rapidity at which a flow rises and falls on average and are important for riparian and aquatic habitat suitability and connectivity, current rates are relatively similar to natural for the both the upper and lower ends of the river segment, with similarity to natural flows of 92% for riverscapes 5 and 6 and approximately 90% for riverscapes 43-45 and 14-16. In the more central riverscapes closer to Lake Catamount (39-41), flow rates of change are relatively less similar to natural (approximately 83-85% of modeled natural flows), though it should be noted that these departures in the greater context are relatively minimal. Together, these results suggest that the rates of flow fluctuations remain relatively similar to modeled natural conditions within the Steamboat segment, with all riverscapes scoring a B or above.

An analysis of data spanning an extended period beyond 1992 at USGS 09239500 (1910-2018) uncovers several findings. At the annual scale, there are non-significant downward trends in both mean and 1-day maximum streamflow (Day 2021). Notably, a more pronounced decrease in daily mean streamflow has been observed for the month of April, with statistical significance. Additionally, a subtle yet noteworthy shift in the date of peak flow occurrence towards earlier in the year has been identified, supported by a marginally significant p-value of 0.06 (Lotic 2021). These observed trends, characterized by earlier peak flow events and a decline in annual streamflow, are consistent with the broader trends observed across the Colorado River Basin. They can be attributed to changing temperature patterns, particularly warming, which have led to reduced winter snowpack and an earlier onset of snowmelt during the spring. The impact of these changes on the riverscape is reflected in the riverscape scores for the overall hydrograph indicator, as detailed in Table 2-2.

Table 2-2. Hydrograph Indicator Scores by Riverscape

Riverscape	Peak Flow Score	Base Flow Score	Total Flow Volume Score	Flow Rates of Change Score	Shifting Peak* Score	Hydrograph Score
Riverscape 5	B-	B	B-	A-	C	C+
Riverscape 6	B	B	B-	A-		B-
Riverscape 39	B-	C+	B-	B		C+
Riverscape 40	B-	C+	B-	B		C+
Riverscape 41	B	B	B	B		B
Riverscape 42	B	B	B	B		B
Riverscape 43	A-	C	B	B+		B-
Riverscape 44	A-	C	B	B+		B-
Riverscape 45	A-	C	B	B+		B-
Riverscape 14	A	B	A-	B+		A
Riverscape 15	A	B	A-	B+		A
Riverscape 16	A	C	B+	B+		A-

* Analysis of the timing of peak flow was done for USGS 09239500. The shifting peak analysis was incorporated holistically into overall scores for all riverscapes.

2.2 SNOWPACK INDICATOR

Much of the Yampa Basin is currently a snowmelt-driven system, meaning that the majority of river flows are derived from a melting snowpack in the springtime as opposed to rainfall or groundwater. In a snowmelt-driven system, snowpack characteristics have a direct effect on the basin's overall flow regime. This indicator considers maximum snowpack depth and associated maximum snow-water equivalent volume, timing of maximum snowpack, and timing from maximum snowpack to peak runoff.

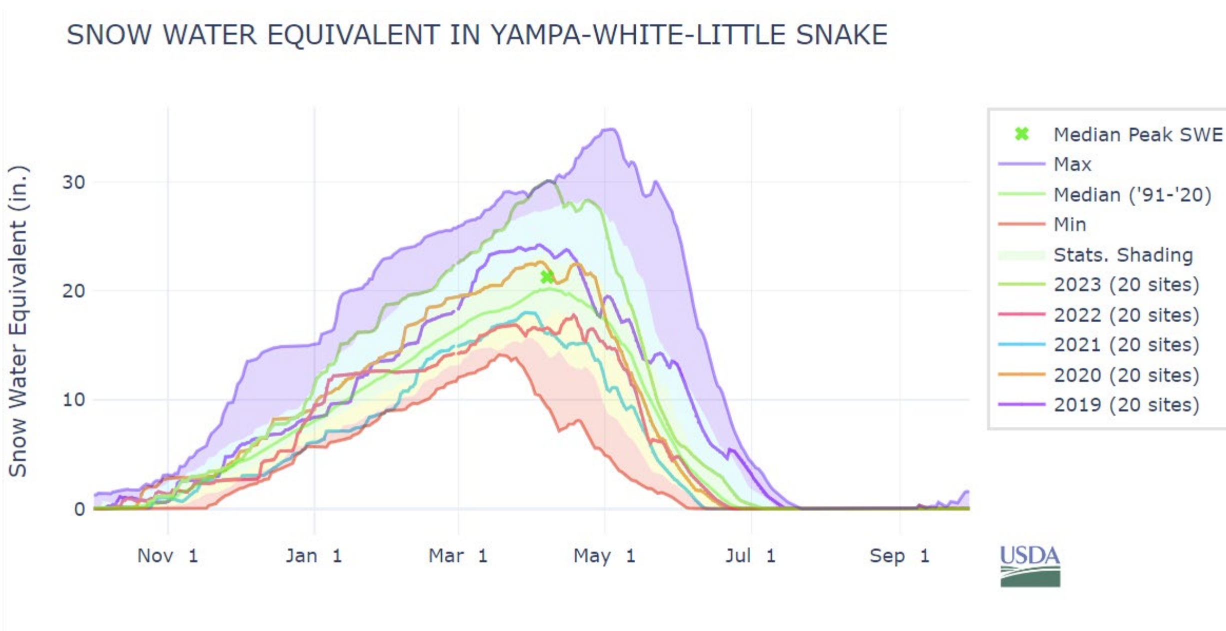
2.2.1 Data Sources and Evaluation Methods

Snowpack data (in the form of snow water equivalent, or SWE) is collected and shared by the Natural Resources Conservation Service (NRCS) collectively for the Yampa, White, and Little Snake River Basins. The NRCS typically compares SWE amounts and timing to the 30-year average and median curves (Figure 2-3). However, in using the NRCS dataset, the Yampa River Scorecard Project obtained data for the entire period of record instead of limiting the analysis to the most recent 30-year average. It also reviewed the locations of SNOTEL sites that generate the SWE data to ensure they are located in the contributing watershed for the current focal segment.

This indicator is evaluated as follows:

(1) Calculate the mean, 95% confidence interval, and standard deviation for maximum SWE (inches) for the period of record;
(2) Calculate the mean, 95% confidence interval, and standard deviation for timing of maximum snowpack (Julian date) for the period of record;
(3) Calculate the date of peak runoff for the USGS 09239500 YAMPA RIVER STEAMBOAT SPRINGS, CO, stream gauge for each year since 1989, and calculate the number of days from maximum snowpack to peak runoff;
(4) Calculate the mean, 95% confidence interval, and standard deviation for maximum snowpack to peak runoff (number of days) for the period of record; and
(5) Review these statistics in light of scoring criteria to rate this indicator for the most recent 5-year period for which data are available (2019-2023).

Figure 2-3. Yampa/White/Little Snake Basins Snowpack Summary for the 2022-23 Water Year



2.2.2 *Scoring Criteria*

The semi-quantitative scoring criteria outlined in Table 2-3 are used to rate the snowpack indicator. Current conditions are considered to be the last five years of data, and the entire period of record for each SNOTEL site used in the analysis is provided in Table 2-4.

Table 2-3. Snowpack Indicator Scoring Criteria

Grade	Description
A	Current snowpack is within the range of historical conditions. Maximum snow-water equivalent (SWE) volume is within the 95% confidence interval (CI) of the period of record. Timing of maximum SWE is within the 95% CI of the period of record. Timing from maximum SWE to peak runoff is within the 95% CI of the period of record.

C	Current SWE volume is within one standard deviation of the period of record. Timing of maximum SWE is within one standard deviation of the period of record. Timing from maximum SWE to peak runoff is within one standard deviation of the period of record.
F	Current SWE volume is greater than one standard deviation from the period of record. Timing of maximum SWE is greater than one standard deviation from the period of record. Timing from maximum SWE to peak runoff is greater than one standard deviation from the period of record.

2.2.3 Results

Seven SNOTEL sites that generate SWE data are located within the contributing watershed for the focal segment (Figure 2-4). Substantial heterogeneity exists in the length of the period of record for each station (Table 2-4), which ranges from 19 years at Bear River to 45 years at Elk River and Tower.

Figure 2-4. Locations of Yampa Steamboat Segment Contributing Watershed SNOTEL Sites

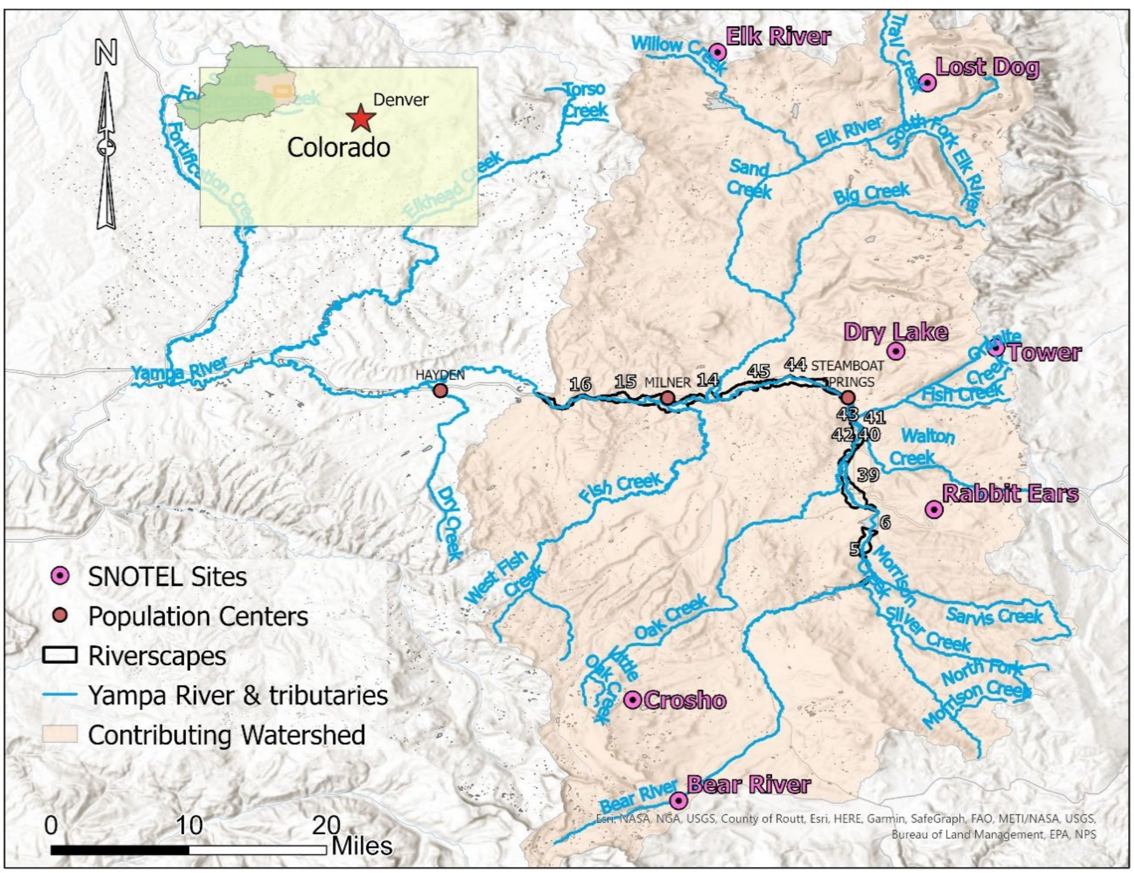


Table 2-4. Yampa Steamboat Segment Contributing Watershed SNOTEL Site Details

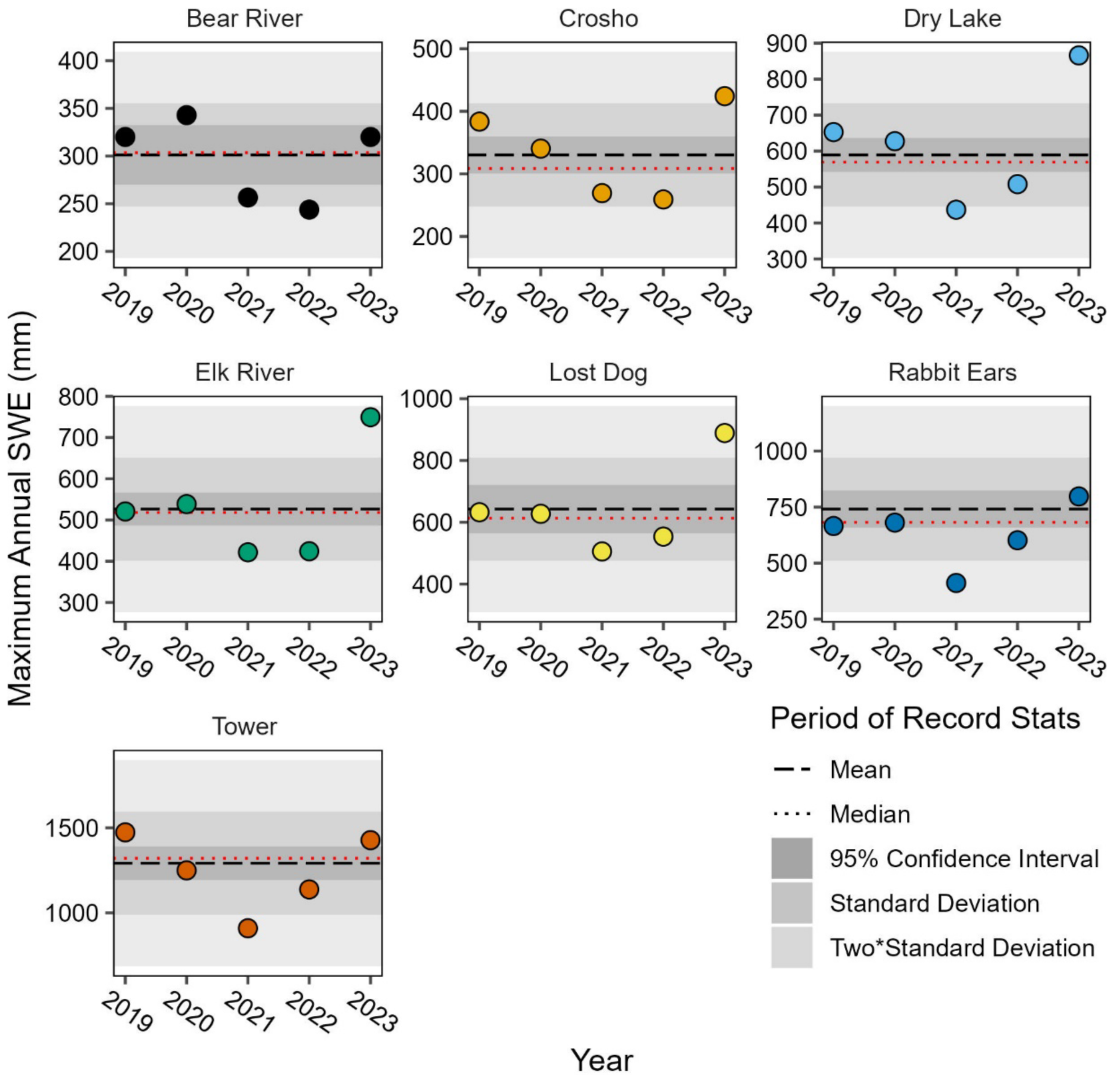
Station	Start Year*	End Year	Elevation (ft)
Bear River	2004	2023	9,113
Lost Dog	1998	2023	9,329
Crosho	1985	2023	8,975
Rabbit Ears	1985	2023	9,411
Dry Lake	1979	2023	8,273
Elk River	1978	2023	8,742
Tower	1978	2023	10,622

*Data begin with first snow of the denoted start year (generally in October)

Figure 2-5 compares the maximum annual SWE volume for the past 5 years of data (2019-2023) to the long-term mean (dashed line), 95% confidence interval (dark gray), and standard deviation (medium gray) generated from the period of record data. Maximum SWE volume over the last five years is generally within a single standard deviation of the period of record mean but outside of the 95% confidence interval (CI), except for the current year (water year 2022-23), which is much higher in many instances (Figure 2-5). In 2021 and 2022, SWE volume is significantly below the mean (i.e., outside the 95% CI) at all SNOTEL stations, though still within a single standard deviation of the mean at 5 of 7 stations (2021 at Rabbit Ears and Tower are the exceptions). SWE volume during the winter of 2019 and 2020 was within the 95% CI at 3 of the seven sites; for just 2020, this increases to 6 of 7 (Bear River was above the 95% CI), while in both 2021 and 2022 this diminishes to 0 of 7 (all sites below the 95% CI). However, in stark contrast to previous years, 2023 SWE volume is significantly above the mean and in four locations greater than one standard deviation from historical means (at Crosho, Dry Lake, Elk River, Lost Dog). Bear River and Rabbit Ears sites are within the 95% CI for 2023, but still above the mean and median, while the remaining site, Tower, is within one standard deviation of the mean. While 2023 volumes represent a significant departure from the mean and median for the period of record in 4 of the 7 locations, increased SWE volume is directly beneficial to the hydrologic regime and overall health of the Yampa River. Therefore, scores range from B- to C for maximum SWE volume for the 5-year examination (Table 2-4).

Figure 2-6 shows the timing of maximum annual SWE volume (day of year) for the past five years of data compared to the long-term mean (dashed line), 95% confidence interval (dark gray), and standard deviation (medium gray) generated from the period of record data. The timing of maximum SWE displays few observable patterns. Overall, the timing of maximum SWE is within a single standard deviation of the mean for all years at 4 of the 7 SNOTEL stations. The exceptions are Tower, Rabbit Ears, and Elk River, which all have one year that falls below a single standard deviation (though within two standard deviations) of the mean. These stations thus earn the lowest scores (Table 2-5).

Figure 2-5. Maximum Annual SWE Volume (2019-2023) Compared to Long-Term Data



Finally, the length of time (i.e., offset) between the timing of peak SWE and the timing of peak streamflow is noticeably different over the most recent five years than the mean for the period of record at each site (Figure 2-7). In general, the offset in 2019 was significantly different than the period of record at all stations besides Tower; 2020 and 2021 were more similar, except for in 2020 at Tower and 2021 at Rabbit Ears. For 2022, however, offset timing was significantly below the long-term mean at 4 of 7 sites. In this scenario, both the maximum SWE volume and the offset between the maximum annual SWE volume and peak river discharge are notably below their respective long-term averages. This signifies that 2022 was a water year characterized by lower-than-usual snow accumulation during the winter, coupled with an earlier snowmelt onset. Consequently, peak river flows failed to reach their typical levels during the peak flow season, potentially leading to decreased water availability and ecological impacts in the Steamboat segment. The combined effect of reduced snowpack and early snowmelt can disrupt the usual hydrological dynamics. This contrasts with 2023 where the maximum SWE was significantly higher than the long-term mean, indicating a substantial accumulation of snowpack. For 2023, provisional peak flow compared with maximum SWE shows that the offset timing returns to within the expected range of variance within the period of record. Scores for this indicator range between B and C- (Table 2-5).

Figure 2-6. Timing of Maximum Annual SWE Volume (2019-2023) Compared to Long-Term Data

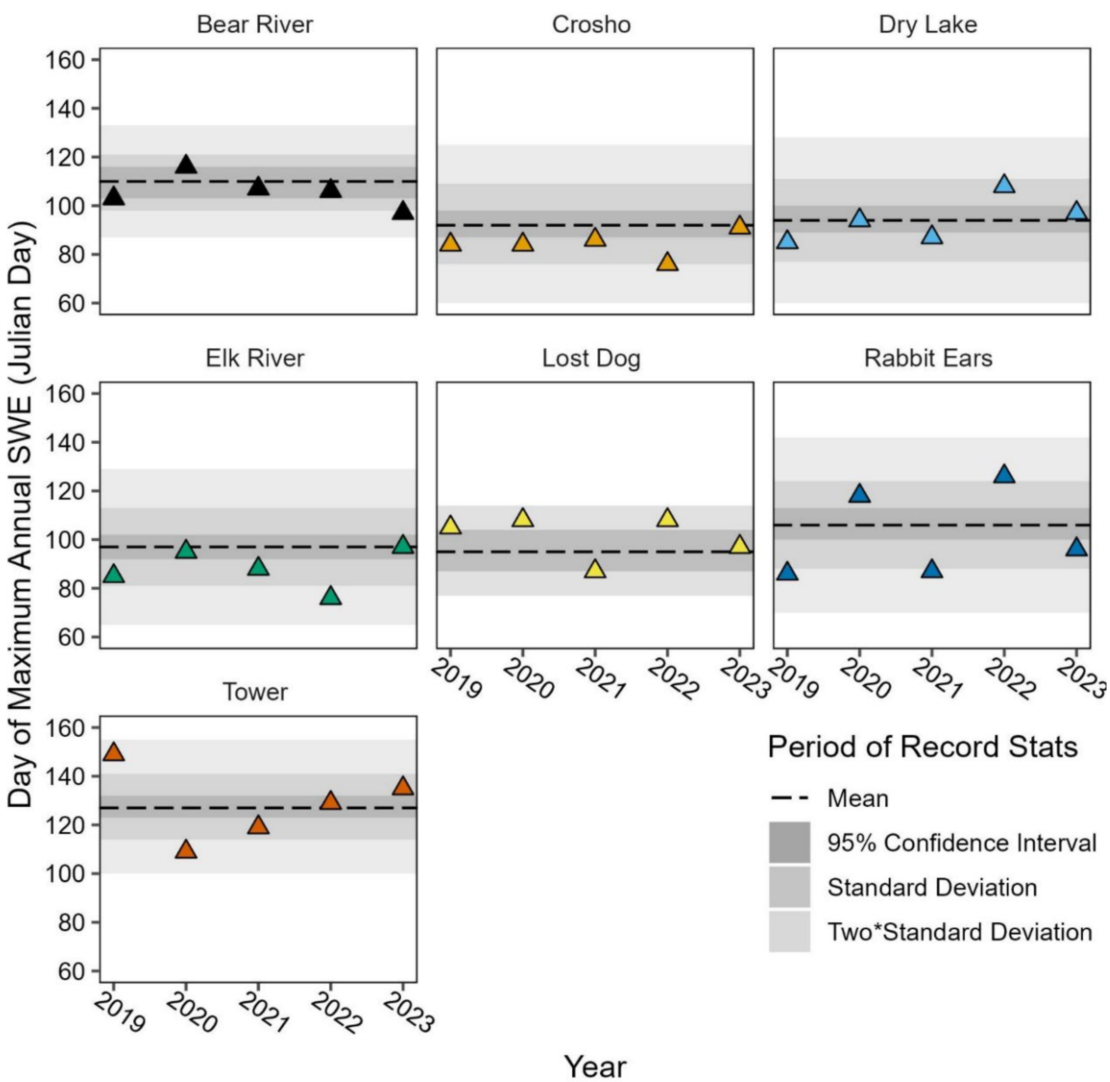
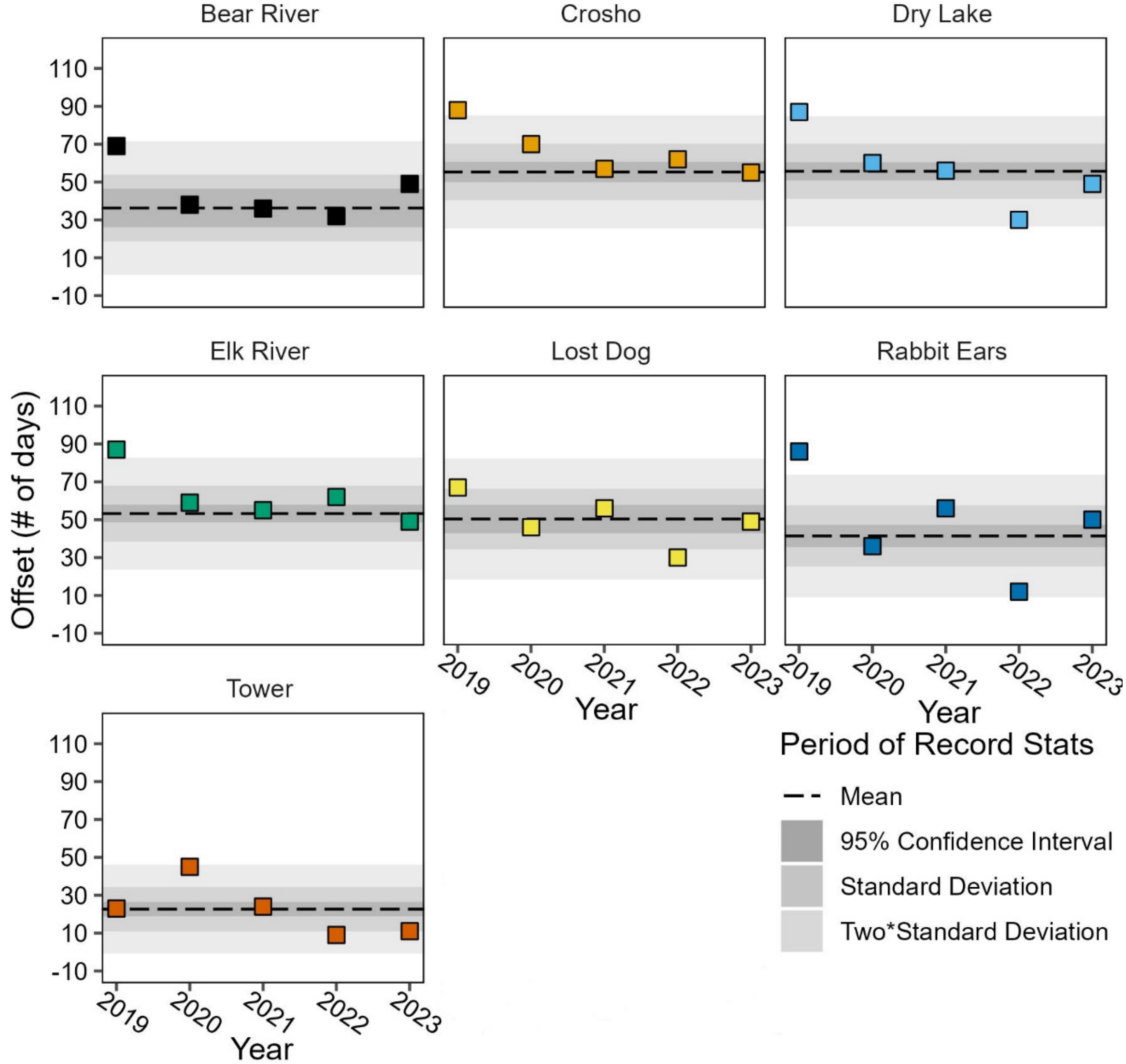


Figure 2-7. Offset of Maximum Annual SWE Volume and Peak River Discharge (2019-2023) Compared to Long-Term Data



Despite the variability between stations, the SNOTEL stations scored a B- for overall score on average; as a result, the snowpack indicator overall receives a score of B- for all riverscapes in the Yampa River Steamboat segment (Table 2-5).

Table 2-5. Snowpack Indicator Scores by SNOTEL Station

Station	Max Score	Timing Score	Offset Score	Overall Score
Bear River	C	B	B+	B-
Crosho	B	B	B	B
Dry Lake	B-	B+	C	B-
Elk River	B	C	B	B-

Lost Dog	B	B+	B+	B
Rabbit Ears	C	C-	C-	C
Tower	C	C	B	C+
Yampa Steamboat Segment (All Riverscapes)	B-			

3.0 SEDIMENT REGIME

Sediment regime is defined as the amount and timing of sediment that all sources, including land erosion in the contributing watershed and upstream channel erosion, supply to a reach, as well as patterns of sediment transport along and out of a reach. The production, transport, and deposition of sediment largely determines channel form and dynamics. Like changes to flow regime, an altered sediment regime can cause significant impacts to stream form and function, including aquatic habitat quality and long-term channel stability, and can damage infrastructure. The Yampa River Scorecard evaluates the system's sediment regime holistically, using a single indicator referred to as **sediment transport and continuity**.

3.1 SEDIMENT TRANSPORT AND CONTINUITY INDICATOR

The sediment transport and continuity indicator considers the ability of the system to maintain natural transport of sediment from its upstream and upgradient sources. For the Yampa River Scorecard Project, this indicator is scored holistically and qualitatively. While sediment transport capacity is predominantly controlled by stream discharge and slope, the number and size of natural and unnatural impediments to sediment transport and the proportion of the reach and watershed from which sediment transport is blocked have a significant impact.

3.1.1 Data Sources and Evaluation Methods

This indicator is scored using expert interpretation of stressors affecting sediment transport, which may be the same stresses affecting other natural processes. Scoring is based on field observations (Appendix A), aerial imagery, and GIS spatial data. Signs of sediment aggradation or degradation outside of natural or expected patterns include disproportionate bar formation, increased bar stabilization, embeddedness by fine-grained material, disproportionate erosion, rapid meander migration, an incised channel with collapsing banks, and/or development of an inset floodplain. Field assessments are completed where appropriate to gain information about streambed substrate composition, stream power, sedimentation, embeddedness, and armoring. The Scorecard public interface explains in layperson terms that erosion and deposition are natural processes that are both critical to maintaining a healthy system, using examples of cottonwood and willow riparian galleries relying on bank erosion and its associated bar and substrate deposition, and bank stabilization practices to limit erosion that just propagate the impact downstream. The Scorecard also presents river stability as a continuum that can be affected by sediment loads, which may lead to either erosion or deposition, but may not necessarily make the river an "unhealthy" one.

3.1.2 Scoring Criteria

Table 3-1 includes the narrative criteria used to rate the sediment transport and continuity indicator. The criteria relate primarily to impediments to sediment transport, signs of sediment balance (or imbalance), and also to the presence of stressors and level of maintenance required to maintain functional river processes.

Table 3-1. Sediment Transport and Continuity Indicator Scoring Criteria

Grade	Description
A	The amount of sediment transported through the reach is optimized to maintain self-sustainable balance with no management or maintenance required. There are only limited, if any, impediments to sediment delivery or transport throughout the reach. Minimal signs of sediment imbalance or disequilibrium are evident.
B	Impediments to sediment transport may exist, but they are either insignificant or they impact sediment balance from only a small portion of the overall contributing area. Minor stressors are present and minimal management or maintenance is required to maintain functionality. Limited signs of sediment imbalance or disequilibrium are evident.
C	Impediments to sediment transport through the reach are notable and are impacting the sediment balance through a moderate portion of the reach. Maintenance and management are required to maintain functionality. Moderate signs of sediment imbalance or disequilibrium are evident.
D	Major impediments to sediment transport exist, yet these impediments either pass a portion of the sediment downstream or block sediment from less than half of the reach. Stressors significantly alter the natural sediment balance, and extensive or consistent active management and maintenance are required. Ample signs of sediment imbalance or disequilibrium are evident.
F	Severe impediments to sediment transport are present and impact most or all of the reach. The sediment balance through the reach is severely altered to a level that results in an inability to support functional processes. Signs of sediment imbalance or disequilibrium are ubiquitous.

3.1.3 Results

The sediment transport and continuity indicator is evaluated through field observations and remote sensing analysis using aerial imagery and GIS spatial data. Review of additional documents, specifically a 2021 USGS report of water quality in the Upper Yampa Basin (Day 2021) and the Yampa River Basin Remote Assessment (Yampa IWMP 2021), was also completed to further augment the analysis. All riverscapes were traversed either on foot or by floating the mainstem, except for approximately 40% of riverscapes 6 and 39.

A USGS investigation of suspended sediment data at the Yampa River below Oak Creek and at Milner gauges indicate that no temporal trend in sediment concentration exists for the period from 2010-2018 (Day 2021). Sediment concentrations were highest during spring runoff and increased in the downstream direction, but no upward or downward trends were found overall. Analysis of the IWMP Middle Yampa priority planning area suggests similarly insignificant trends of approximately the same time period. Although this analysis did not cover segments within the Steamboat segment, results suggest a steady sediment regime over time (Yampa IWMP 2021). Together, these analyses converge on the idea that the sediment regime through the Steamboat segment has remained steady over the better part of the last three decades.

Examining field-collected data reveals that deposition and erosion indicative of healthy river (e.g., meandering) were observed in all riverscapes (Appendix A, Photos A-1 through A-4).

Embeddedness is additionally very low (<5%) to moderately low (10-20%) at all sampling sites (refer to Section 9.2 for more information). However, other metrics such as those related to connectivity and riparian condition show consistently lower scores in the Steamboat segment compared to the Middle Yampa segment, despite a higher prevalence of restoration actions. This discrepancy is primarily attributed to the persistent and widespread human-induced alterations found in the Steamboat segment. Factors including artificial confinement, extensive in-channel manipulation, and prevalent stressors such as infrastructure and development contribute to the observed challenges in sediment dynamics. This assessment aims to dissect these specific influences, providing a straightforward understanding of why the Steamboat segment exhibits lower sediment transport and continuity indicator scores in comparison to its downstream neighbor.

As might be expected, the lowest sediment transport and continuity scores are found in riverscapes 42 and 43 where the highest concentration of development and channel manipulation exists. Both riverscapes exhibit frequent long stretches of armoring, in-channel structure placement, and channel straightening measures limiting complexity (Section 5.1; Appendix A, Photos A-5 through A-8, Photos A-9 through A-11, and Photo A-13, respectively). The higher degree of development and low connectivity (Section 6), as well as high levels of floodplain fragmentation (Section 5.2) also leads to a decrease in sediment availability from the surrounding floodplain. In a slightly better condition, riverscapes 40 and 41 are less impacted by the City of Steamboat Springs but contain evidence of widespread and persistent manipulation limiting mobility and complexity. Slightly more frequent evidence of erosional and depositional features are present, but in-channel structures and frequent instances of armoring and channel stabilization also occur.

At the upstream end of the Steamboat segment, riverscape 5 is confined by both natural morphology (i.e., bedrock) and road infrastructure. Manipulation of the bed in the form of boulder placement and rock structures have been positioned to further limit mobility in the upper and lower ends, the most confined portions (Appendix A, Photos A-13 and A-14). The middle third of riverscape 5 opens up and is less impacted by confinement but has frequent instances of erosion and actively collapsing banks with limited depositional features due to agricultural activity. However, the biggest impact is that of Stagecoach reservoir which limits natural sediment transport from further up in the watershed. This limitation is moderated by contributions from Sarvis Creek, which joins the Yampa River from the wilderness area, and, temporarily, by Morrison Creek due to increased sediment loads from the 2021 Muddy Slide Fire burn scar (Appendix A, Photos A-15 and A-16).

Restoration actions and placement of in-channel structures intended to improve fish habitat and stabilize banks are prevalent throughout riverscapes 6 and 39, although different approaches were used. Therefore, although some bar and erosional features are present, the existence of natural erosional or depositional processes is limited, as well as the ability of these riverscapes to exhibit natural complexity and lateral mobility over time. The upper portions of both riverscapes especially are actively managed to maintain the present channel configuration, as built for restoration in riverscape 6, and as needed to protect infrastructure and land in riverscape 39.

Riverscape 14 exhibits the highest relative score in terms of sediment dynamics. In riverscape 14, the river is well-connected to the available floodplain with minimal impacts from adjacent road/rail infrastructure. Signs of deposition and transport, indicative of a healthy dynamic river system, are prevalent, and ample space is available for these processes to be maintained. Although some inhibitions to natural sediment transport processes exist, such as armoring (e.g., rock and rip rap, Appendix A) these instances are minimal compared to adjacent reaches. Notably, the presence of lateral mobility (e.g., erosion, side channel development), wood accumulation, and beaver activity suggests a moderately well-functioning sediment system (Appendix A, Photos A-17 through A-20). There are also favorable contributions from the Elk River that support the continued development of depositional features (e.g., bars, islands, side channels) and complexity within the segment (Appendix A, Photos A-21 through A-27). Upstream of riverscape 14, riverscapes 44 and 45 are similarly well-functioning but with limited connectivity and more frequent instances of bank stabilization features, reduced complexity, and limited depositional features. However, despite the influence of the Elk River, riverscapes 15 and 16 are more impaired than their upstream counterparts by barriers to lateral movement and longitudinal transport of sediments. These riverscapes are both naturally more confined and also constrained by US Highway 40 and the Union Pacific railroad infrastructure (Appendix A, Photos A-28 through A-31). Significantly more instances of armoring and in-channel flow control structures are present, resulting in a more simplified system with reduced complexity.

The assessment of sediment transport in the Steamboat segment reveals persistent impacts, primarily attributed to human-induced alterations such as confinement, bank protection, in-channel manipulation, and infrastructure development. Despite these challenges, pockets of natural sediment processes remain observable, offering opportunities for targeted interventions to enhance sediment dynamics and promote a healthier river system. Scores for each riverscape based on the above examination are listed in Table 3-2.

Table 3-2. Sediment Transport and Continuity Indicator Scores by Riverscape

Riverscape	Sediment Transport/Continuity Score
Riverscape 5	B-
Riverscape 6	C+
Riverscape 39	C+
Riverscape 40	C-
Riverscape 41	C-
Riverscape 42	D
Riverscape 43	D-
Riverscape 44	A-
Riverscape 45	A-
Riverscape 14	A
Riverscape 15	B
Riverscape 16	B+

4.0 WATER QUALITY

Water quality is defined as the physico-chemical characteristics of water in a river segment, and it is influenced by natural geological weathering, biogeochemical processes, and human activities (upstream land and water uses). Suitable water quality in streams supports recreational uses, ensures public health, and supports wildlife and fish habitat. The Yampa River Scorecard uses several indicators to evaluate water quality. The list of indicators is based on feedback from the Technical Committee and contains parameters that are relatively easy to measure and/or for which data already exist. The six water quality indicators are **temperature, dissolved oxygen, pH, macroinvertebrates, nutrients, and metals**. The final water quality score is calculated as an average of the six indicator scores.

Water quality measurements that can be important for assessing stream health include parameters that fall into the following categories: (1) standard physical parameters that can be measured *in situ* with a handheld water quality instrument that provides instantaneous results (e.g., temperature, pH, conductivity, dissolved oxygen, oxidation-reduction potential, turbidity); (2) analytes that require water samples to be collected and sent to a laboratory for analysis (e.g., total and dissolved metals, nutrients); and (3) biological indicators of water quality (e.g., macroinvertebrates). This section provides more detail on the six indicators included in the Yampa River Scorecard.

4.1 TEMPERATURE INDICATOR

Water temperature is measured using a standard water quality meter or a thermometer. The ranges of many aquatic species are limited by temperature, so this parameter is an important measure of habitat quality. Shading from the riparian canopy, good hyporheic exchange, and seepage from spring-fed tributaries (in some cases) contribute to lower temperatures that support the cool- and cold-water fish species present in Colorado streams and rivers. The CDPHE Stream Classifications for Aquatic Life with the Steamboat segment are as follows:

- Yampa mainstem from Stagecoach Reservoir to Oak Creek (Yampa River Segment 02a): Aquatic Life Cold Water 1 and Cold Stream Tier I[1] (CS-I) temperature standards.
- Yampa mainstem from Oak Creek to Elkhead Creek (Yampa River Segment 02b): Aquatic Life Cold Water 1 and Cold Stream Tier II[2] (CS-II) temperature standards (with Mountain Whitefish (MWF) site-specific standards (SSS) in the shoulder season months of April, May, and October[3]) with a temporary modification (more information below; CDPHE 2021)

The Aquatic Life Cold Water 1 classification applies to riverscapes 5, 6, and 39; the Aquatic Life Cold Water 1 with temporary modifications classification applies to the nine remaining

[1] WQCC Regulation 31, page 52: "Cold Stream Tier I temperature criteria apply where cutthroat trout and brook trout are expected to occur."
[2] WQCC Regulation 31, page 52: "Cold Stream Tier II temperature criteria apply where cold-water aquatic species, excluding cutthroat trout or brook trout, are expected to occur."
[3] WQCC Regulation 31, page 52: "Mountain whitefish-based summer temperature criteria [16.9 (ch), 21.2 (ac)] apply when and where spawning and sensitive early life stages of this species are known to occur."

riverscapes in the Steamboat segment. These stream segment classifications are further subject to specific water quality standards set by CDPHE, including water temperature standards (Table 4-1). The City of Steamboat Springs has identified non-attainment of the in-stream temperature standards in Segments 02a and 02b (as well as CS-I tributaries to the Yampa River mainstem). While some thermal sources have been identified, other sources remain uncertain at this time. In response, an increased effort to identify and mitigate contributions from warming sources has been implemented.

Table 4-1. Temperature Water Quality Standards in Yampa River Segments 02a and 02b

Month	Yampa River Segment 02a (CS-I Temperature Standards)		Yampa River Segment 02b (CS-II Temperature Standards + SSS for MWF)	
	Acute Standard (deg C)	Chronic Standard (deg C)	Acute Standard (deg C)	Chronic Standard (deg C)
January	13.0	9.0	13.0	9.0
February	13.0	9.0	13.0	9.0
March	13.0	9.0	13.0	9.0
April	13.0	9.0	21.2	16.9
May	13.0	9.0	21.2	16.9
June	21.7	17.0	24.3	18.3
July	21.7	17.0	24.3	18.3
August	21.7	17.0	24.3	18.3
September	21.7	17.0	24.3	18.3
October	13.0	9.0	21.2	16.9
November	13.0	9.0	13.0	9.0
December	13.0	9.0	13.0	9.0

Instantaneous measurements of water quality taken manually have limited value when considering optimal conditions for resident aquatic species. Continuous temperature data loggers that collect temperature measurements at regular intervals provide a greater understanding of the conditions impacting aquatic habitat and allow for comparison with water quality temperature standards. These are relatively inexpensive but can be tricky to install in a system like the Yampa River Basin that sees large fluctuations in flows, freezing during winter months, visitation by curious individuals or animals, and other challenging conditions for field monitoring.

4.1.1 Data Sources and Evaluation Methods

Continuous temperature measurements are collected by USGS every 15 minutes at stream gauge 09239500 (Yampa River at Steamboat Springs, CO), seasonally (May-August) at gauge 09240020 (Yampa River Below Soda Creek at Steamboat Springs, CO), and DWR collects hourly measurements at the YAMABVCO gauge (Yampa Above Lake Catamount). Additionally, temperature loggers (HOBO pendant loggers) were deployed by FOTY in coordination with the City of Steamboat Springs between September 2022 and October 2023 (Table 4-2, Figure 4-1). Temperature data loggers deployed as part of the Scorecard effort follow the same protocols for equipment installation and retrieval as the City of Steamboat Springs in order to maintain consistency across the Yampa basin; additional details are provided in the Yampa River Scorecard Project Indicators and Methods Report (FOTY/Alba Watershed Consulting 2021).

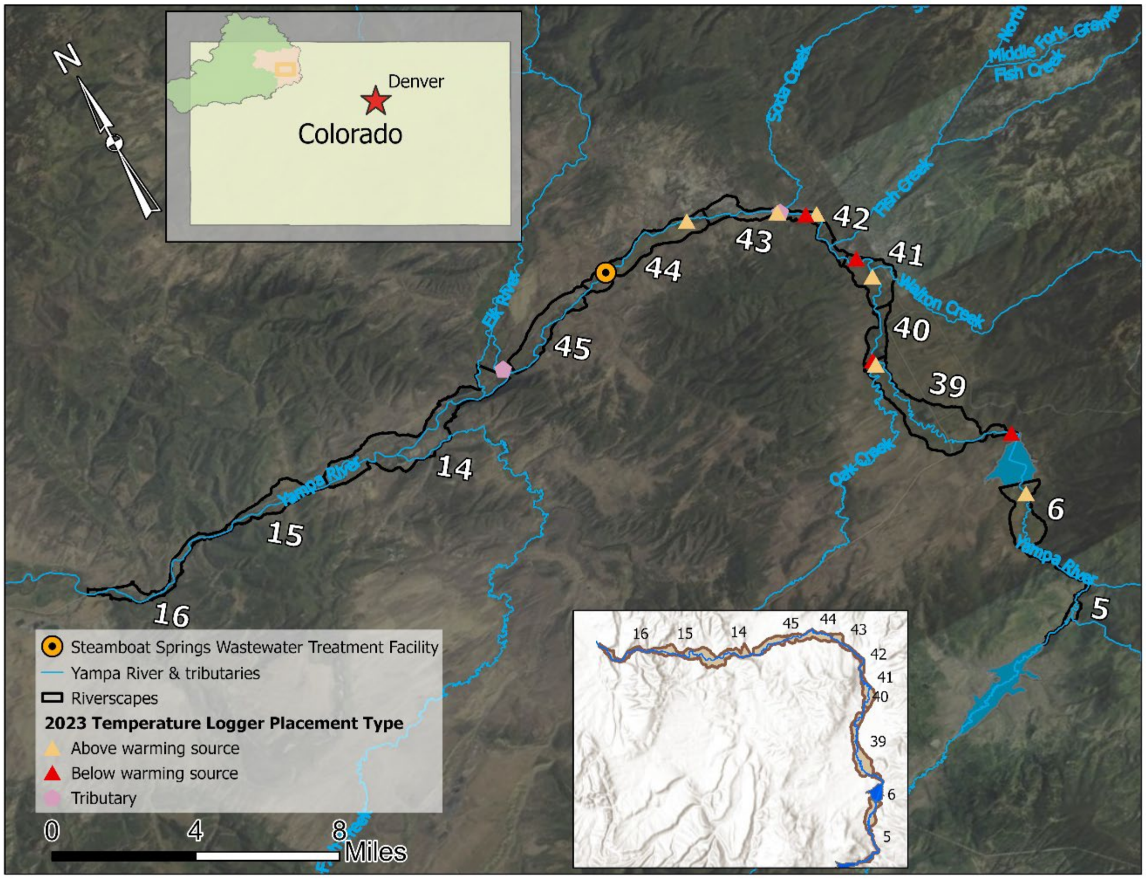
All riverscapes within the Steamboat segment are designated on the State's 303(d) list of impaired waterbodies for stream temperature, indicating concerns about the impact of temperatures on aquatic life throughout the year. To address these concerns, multiple agencies collaborate on temperature monitoring, employing both continuous and discrete measurements. These efforts also involve inquiries into mitigation measures aimed at improving the overall temperature regime. Additionally, Colorado Parks and Wildlife (CPW) strategically places continuous loggers in critical areas known for supporting diverse aquatic species. The City of Steamboat Springs has actively engaged in monitoring efforts since 2016 when the Yampa River segment 2b was placed on the 303d list.

While there is a wealth of temperature data available from these diverse sources, the Scorecard focuses specifically on the analysis of data listed in Table 4-2 and shown in Figure 4-1. This focused approach aims to provide clarity and ease of access to the most pertinent information, and accounts for the fact that there is considerable overlap of efforts in some locations. However, it is important to recognize the broader watershed-wide efforts and ongoing discussions among stakeholders aimed at identifying comprehensive solutions to address the overarching temperature challenges in this segment and the watershed as a whole.

Table 4-2. Temperature Monitoring Locations in the Steamboat Segment

FOTY/City of Steamboat Springs Managed		
Site Name	**Deploy Date**	**Retrieval/ Redeployment Date**
Yampa River Above Walton Creek	2022-09-08	2023-08-30
Yampa River at Rotary Park	2022-09-08	2023-08-28
Yampa River Above Old Town Hot Springs Effluent Site	2022-09-09	2023-08-31
Yampa River below Chuck Lewis CWA Bridge	2022-09-08	NA - Buried
Yampa River above Oak Creek	2023-10-10	NA
Soda Creek at Confluence with Yampa	2022-09-09	2023-09-21
Yampa River at Pirate Put-in	2023-08-28	2023-10-11
Elk River At Confluence with Yampa	2023-08-28	2023-10-11
Yampa River at Catamount Tailout	2023-08-31	2023-10-10
CO DWR/USGS Managed		
Site Name	**Data Retrieval Start**	**Data Retrieval End**
YAMABVCO (Yampa River Above Lake Catamount Near Steamboat Springs)	2022-10-01	2023-09-30
09239500 (Yampa River at Steamboat Springs, CO)	2022-10-01	2023-09-30
09240020 (Yampa River Below Soda Creek at Steamboat Springs, CO)	2023-05-01	2023-09-01

Figure 4-1. Locations of 2023 Temperature Loggers and Gauges Included in Data Analysis



4.1.2 Scoring Criteria

The temperature indicator scoring criteria outlined in Table 4-3 are based on regulatory standards outlined in CO Regulation 33 (CDPHE 2023). These criteria are not quantitative; rather, they rely on consulting current regulatory standards.

Table 4-3. Temperature Indicator Scoring Criteria

Grade	Description
A	Temperature regime is natural and appropriate for a well-functioning river in its process domain.
B	Temperature regime is within the range of natural variability. Natural aquatic biota may be minimally impaired. Regulatory standards are not exceeded.
C	Temperature regime is altered to a degree that could significantly affect natural aquatic biota. Regulatory standards are occasionally exceeded. CDPHE Monitoring and Evaluation (M&E) listed reaches fall in this category.
D	Temperature regime is altered to a degree that is known to affect natural aquatic biota. Regulatory standards are frequently exceeded. CDPHE 303(d) listed reaches fall in this category.

F	The temperature regime is fundamentally altered. Natural biota are severely impaired. Regulatory standards are chronically exceeded.

4.1.3 Results

Recent temperature modeling described in the report "Reducing Uncertainty in Water Temperature Modeling on the Yampa River near Steamboat Springs" indicates significant contributions to warming downstream of the Lake Catamount area (City of Steamboat Springs/Lotic 2023). Despite its relatively small surface area, Lake Catamount disproportionately influences downstream warming due to temperature stratification, leading to the release of the warmest waters over the spillway. Seasonal lags in warming and cooling further compound downstream thermal exceedances, particularly in late summer.

In a broader context, the City of Steamboat Springs is actively engaged in investigating warming sources and exploring mitigation strategies to reduce uncertainty. While the City's Wastewater Treatment Facility (WWTF) effluent is a known potential source and undergoes intensive monitoring, it contributes cooler water than the river during months of non-attainment and is therefore likely not contributing to elevated temperatures in the Steamboat segment. Other potential contributors, such as Lake Catamount (which is generally shallow and warm), hot springs, climate change, and land use changes, add to the complexity of the temperature story, exacerbating the level of uncertainty surrounding sources in general. To address these challenges, various measures have been implemented. Protection of riparian vegetation and continued riparian plantings to increase river shading, strategic flow releases from Stagecoach Reservoir, and changes in operations at Lake Catamount, including the adjustment of water withdrawal from more favorable temperature strata, are among the proactive steps taken to manage and mitigate temperature influences.

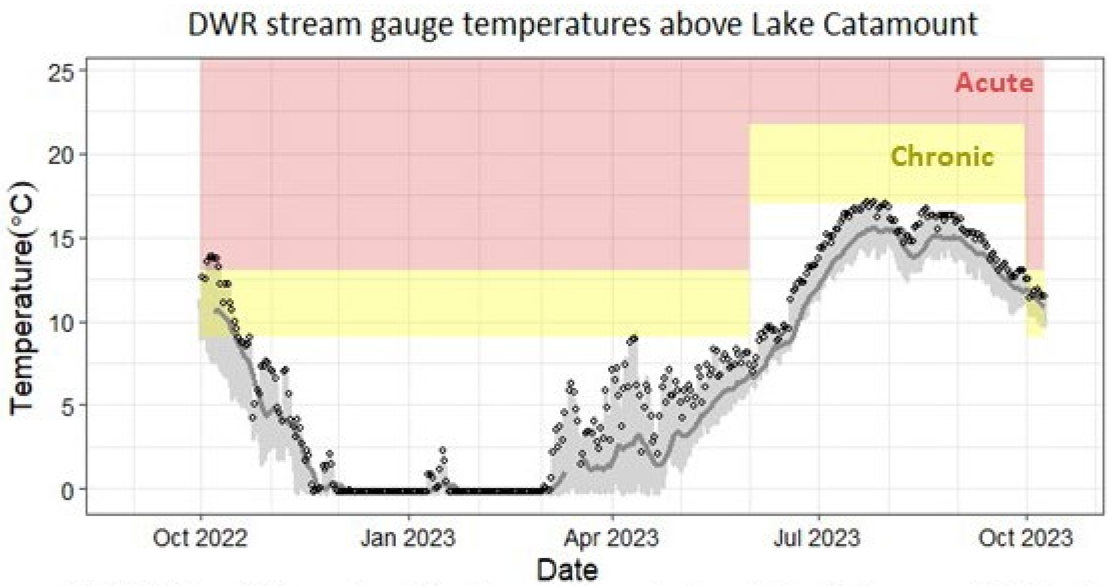
With this background fully explored in numerous reports (Bauch et al. 2012, Day 2021, Yampa IWMP 2021, Lotic 2021, City of Steamboat Springs/Lotic 2023), the Scorecard project seeks to provide additional relevant insight, without confounding or contradicting previous findings. The following analysis focuses on the latest data from Table 4-2, specifically assessing whether ongoing concerns persist. While a wealth of additional information contributes to the broader temperature narrative, this year's focus is on finer-scale patterns of warming for a more nuanced understanding. Each riverscape receives a D score in accordance with the scoring criteria because each riverscape is 303(d) listed for temperature (Table 4-4), but the following discussion provides additional perspective.

The temperature indicator for the Steamboat segment is evaluated through the analysis of seven HOBO temperature loggers deployed by FOTY in coordination with the City of Steamboat Springs. In a deliberate effort to complement work being completed to untangle the uncertainty surrounding warming sources, FOTY placed these loggers above and below known or suspected warming sources. Four loggers collected approximately 12 months of temperature data (Walton, Rotary, OTHS, Soda Creek), and three collected approximately two months of data (Pirate, Elk River, Catamount). Two additional placements were made to bracket the Oak Creek tributary, but one (upstream of Oak Creek) was installed late in the season and the other (downstream of Oak Creek) could not be retrieved due to likely burial by more than a foot of sediment. USGS and CO DWR stream gauge continuous temperature data were also evaluated where possible, with 12 months of data available at two gauges (09239500 and YAMABVCO) and four months available at the third (09240020). Temperature loggers managed by FOTY and the City of Steamboat Springs collected at 30-minute intervals and USGS and DWR gauges collected at 15-minute intervals (DWR is analyzed by hourly average). Results were evaluated against current regulatory standards, primarily the daily maximum (DM) temperature or acute standard, which regulates the maximum temperature that can occur over a 24-hr period, and the maximum weekly average temperature (MWAT) or chronic standard, which sets the maximum allowable temperature for the rolling 7-day mean of daily average temperature (CDPHE 2023). Where applicable, standards under the temporary modification for temperature were incorporated into the analysis (CDPHE 2021).

Evaluation of paired monitoring locations above and below known or suspected warming sources reveals the following results. In riverscape 39 below Lake Catamount, consistent exceedances of regulatory DM standards (13°C) during the late fall are observed (Figure 4-2). However, upstream conditions, representing conditions in riverscapes 5 and 6, show only regular MWAT (9°C) exceedances during the late fall for the same period (September 1-October 9, 2023). This finding is consistent with indications of Lake Catamount as a warming source. A similar pattern is seen at the effluent site for Old Town Hot Springs in riverscapes 42 and 43 (Figure 4-3). The upstream monitoring location shows persistent MWAT (18.3°C) exceedances in summer to fall, but not exceedances of the DM (24.3°C) regulatory standard. However, the downstream monitoring location, below the effluent from the hot springs, shows multiple daily maximums that exceed the acute DM regulatory standard during the height of summer when aquatic species are the most stressed (Yampa IWMP 2021). It is important to note that the weekly average did not exceed DM standards at this location. Breaking with this pattern, Walton Creek had no significant differences in temperatures above the confluence when compared to below (Figure 4-4). This was true throughout the year and there were no periods of notable DM exceedances. However, at both Walton Creek monitoring locations, influenced by riverscapes 40 and 41, daily maximums and weekly averages consistently exceeded the MWAT (18.3°C) standard, again during periods of low flow and higher air temperatures (July-September).

Additional analysis of the rest of the temperature logger data will be completed in the next Scorecard cycle for this segment when data over a longer timeframe are available. However, based on the data analyzed and in accordance with the scoring criteria, all riverscapes in the Steamboat segment are assigned a D score for this indicator due to their 303(d) listing for temperature (Table 4-4). The City of Steamboat's Yampa River Health Assessment and Streamflow Management Plan (2018) attributes elevated temperatures, particularly during droughts, to potential causes like reduced shading from riparian forest degradation and increased thermal gains in Lake Catamount, as has been documented numerous times elsewhere (Bauch et al. 2012, Day 2021, City of Steamboat Springs/Lotic 2023). USGS (2020) data indicate decreasing streamflow trends in the Yampa River basin, especially during spring and summer correlating with broader trends across the Colorado River Basin and western US (Yampa IWMP 2021). With Stagecoach Reservoir's presence since 1988, all monitoring locations along the Yampa River mainstem exhibit significant decreasing streamflow trends. Reduced streamflows and shallower depths can elevate water temperatures, further exacerbated during droughts. The potential impacts of increasing ambient air temperatures related to climate change and increasing development pressure suggests future challenges in maintaining suitable water temperatures for aquatic biota.

Figure 4-2. Paired Temperature Data from Above and Below Lake Catamount



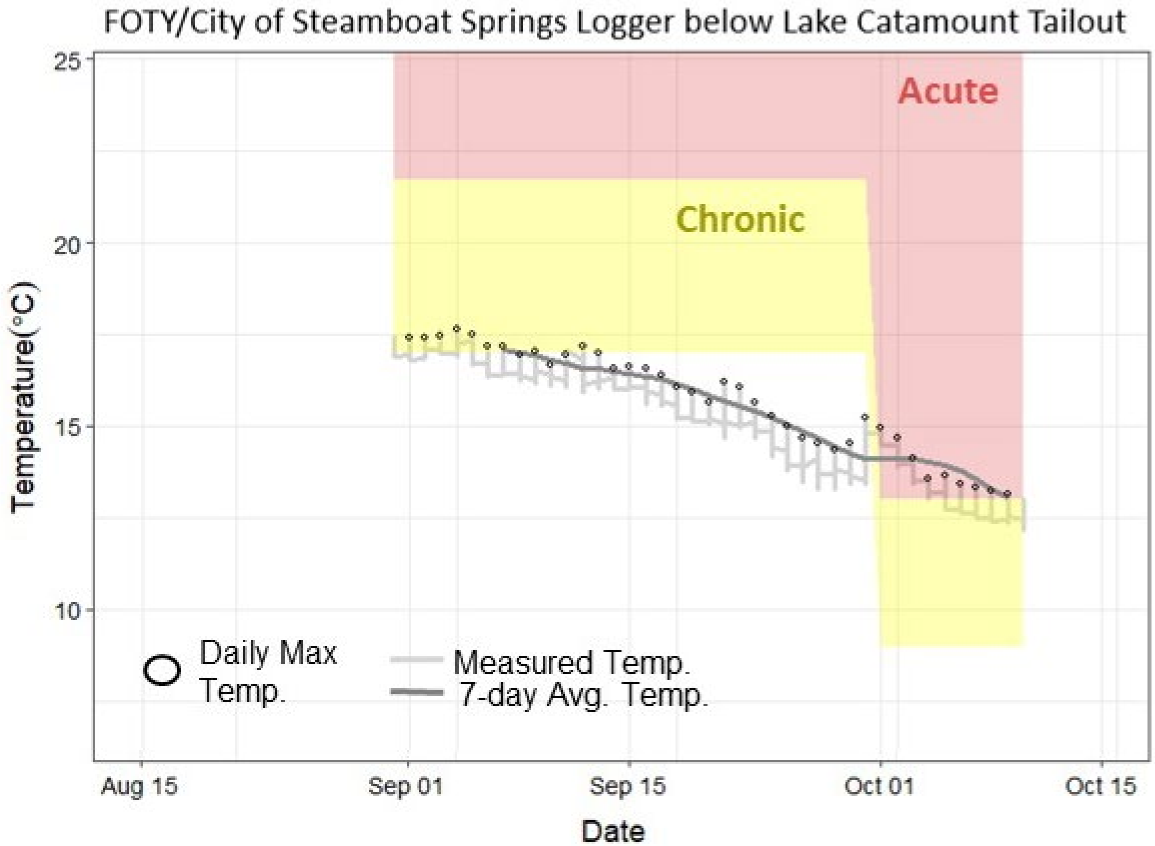
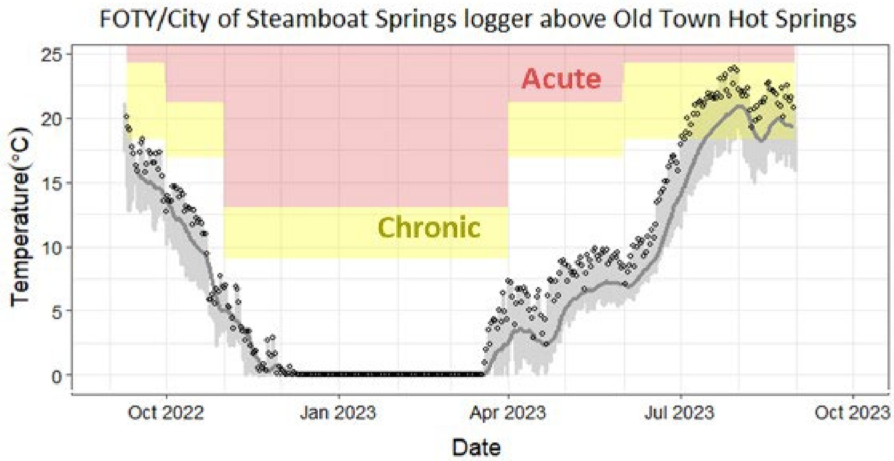


Figure 4-3. Paired Temperature Data from Above and Below Old Town Hot Springs



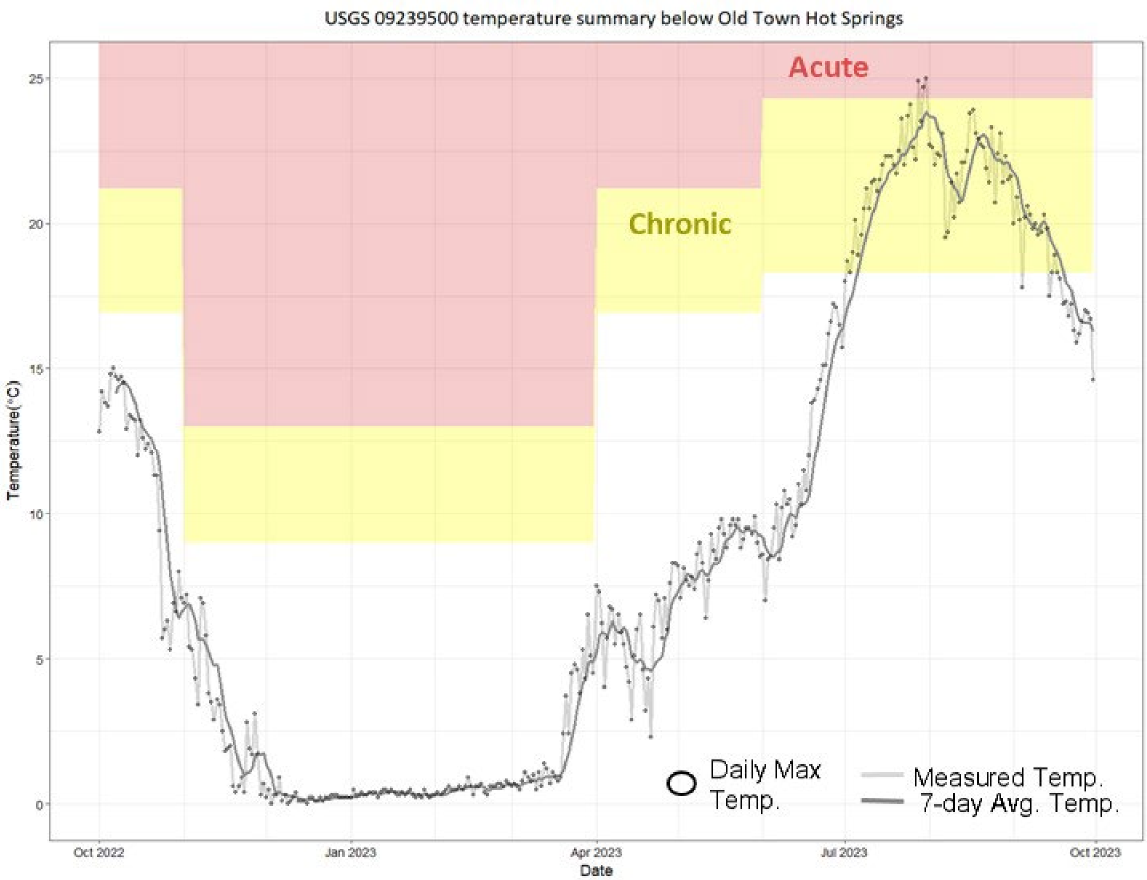


Figure 4-4. Paired Temperature Data from Above and Below Walton Creek Tributary

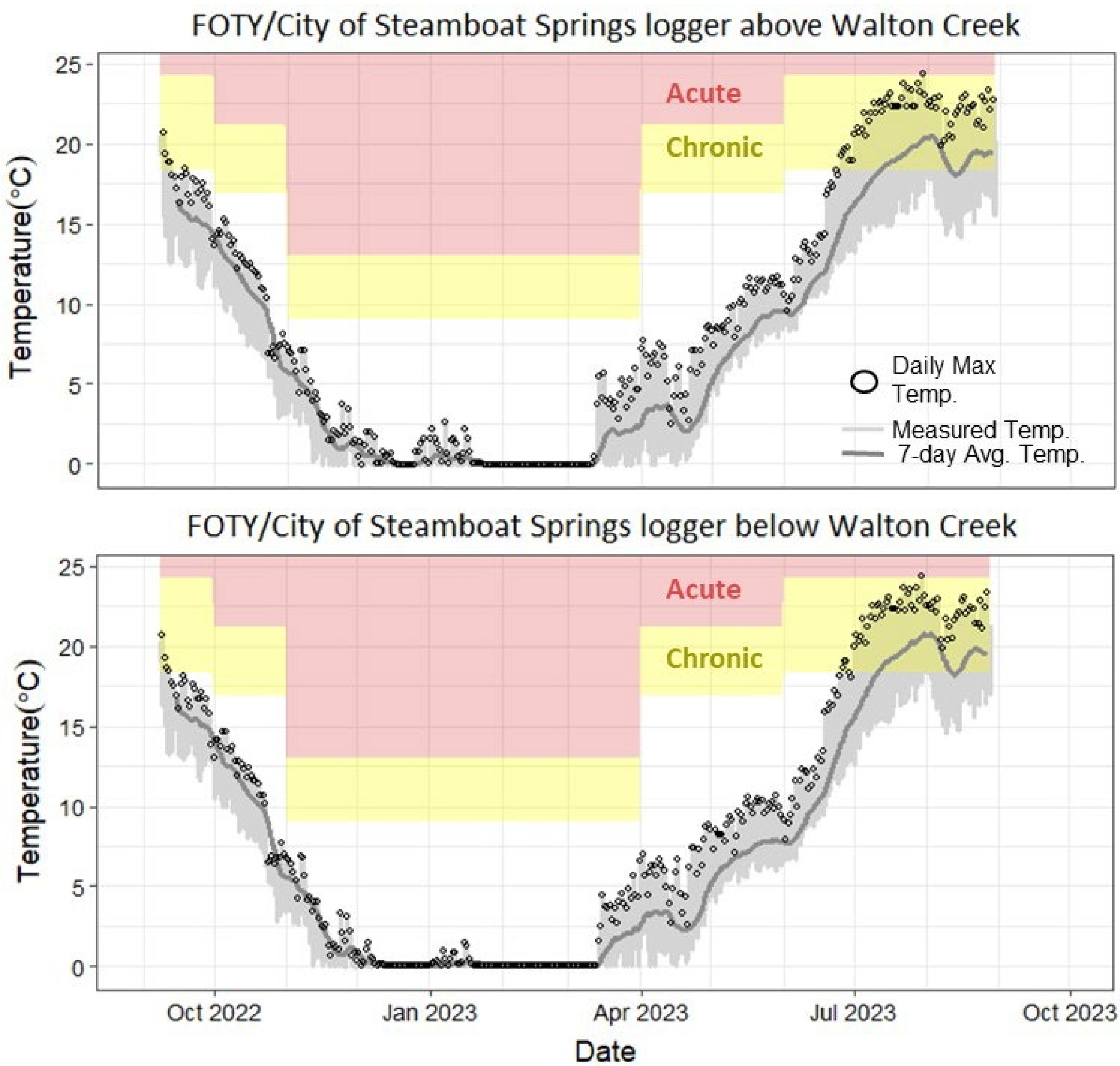


Table 4-4. Temperature Indicator Scores by Riverscape

Riverscape	Temperature Score
Riverscape 5	D
Riverscape 6	D
Riverscape 39	D
Riverscape 40	D
Riverscape 41	D

Riverscape 42	D
Riverscape 43	D
Riverscape 44	D
Riverscape 45	D
Riverscape 14	D
Riverscape 15	D
Riverscape 16	D

4.2 DISSOLVED OXYGEN INDICATOR

Dissolved oxygen (DO) is the amount of free oxygen present in the water column and is important for the survival of fish and other aquatic species. To ensure accurate readings when using a water quality meter to record DO, the meter must be suspended in the water column and out of direct contact with the stream bed, which is sometimes difficult in shallow streams.

4.2.1 Data Sources and Evaluation Methods

Field-based water quality parameters including dissolved oxygen are measured quarterly by USGS as part of the Upper Yampa River Basin Water Quality Monitoring Program. Three locations in the Steamboat Scorecard focal segment are part of this monitoring program: Yampa River below Oak Creek; Yampa River at Steamboat Springs, CO; Yampa River at Milner, CO. Data were downloaded from nwis.waterdata.usgs.gov.

4.2.2 Scoring Criteria

Similar to temperature, the dissolved oxygen scoring criteria outlined in Table 4-5 are based on regulatory standards.

Table 4-5. Dissolved Oxygen Indicator Scoring Criteria

Grade	Description
A	Dissolved oxygen concentrations are natural and appropriate for a well-functioning river in its process domain.
B	Dissolved oxygen concentrations are within the range of natural variability. Natural aquatic biota may be minimally impaired. Regulatory standards are not exceeded.
C	Dissolved oxygen concentrations are altered to a degree that could significantly affect natural aquatic biota. Regulatory standards (6.0 mg/L or 5.0 mg/L) are occasionally exceeded. CDPHE Monitoring and Evaluation (M&E) listed reaches fall in this category.
D	Dissolved oxygen concentrations are altered to a degree that is known to affect natural aquatic biota. Regulatory standards (6.0 mg/L or 5.0 mg/L) are frequently exceeded. CDPHE 303(d) listed reaches fall in this category.

F	Dissolved oxygen concentrations are fundamentally altered. Natural biota are severely impaired. Regulatory standards are chronically exceeded.

4.2.3 Results

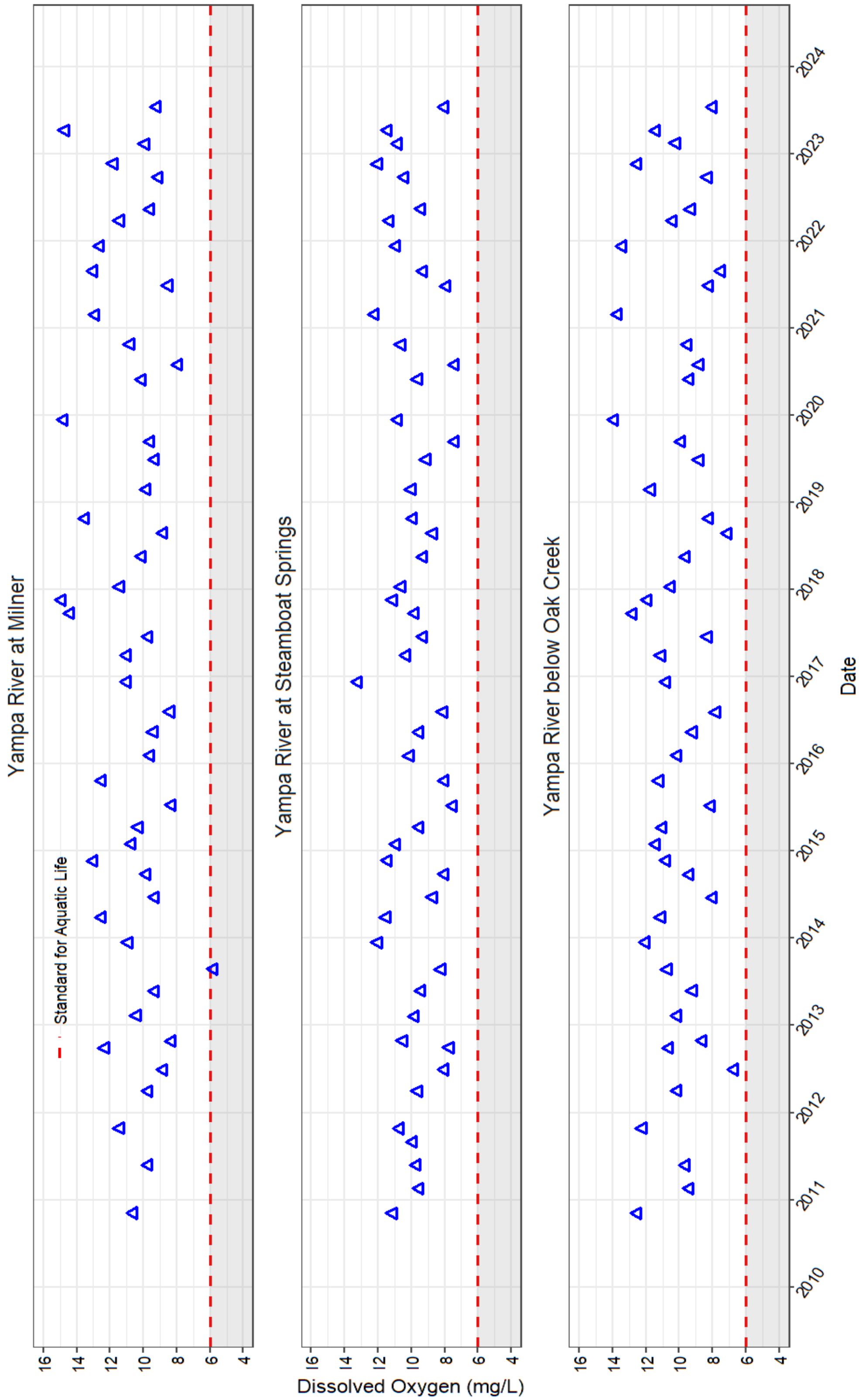
The dissolved oxygen indicator is evaluated through review of USGS Water Quality Monitoring Program data at the Yampa River below the Oak Creek confluence, and in the population centers of Steamboat Springs and Milner, CO. Because rivers integrate upstream inputs, data from the Oak Creek station (located in riverscape 39) are used to score riverscapes 39, 6, and 5; data from the Steamboat (located in riverscape 43) are used to score riverscapes 43, 42, 41, and 40; and the remaining riverscapes (16-14 and 45-44) are scored using the Milner station.

Dissolved oxygen concentrations at both the Oak Creek and Steamboat stations are well above the standard for aquatic life for each year between 2010 and 2023 (Figure 4-5). Concentrations at Milner for most years in this time frame are also above this threshold, except for a single observation in late summer 2013 when DO dropped slightly below the standard. Despite this isolated incident, each riverscape is within healthy standards and is functional for this parameter; therefore, all riverscapes receive an A score (Table 4-6).

Table 4-6. Dissolved Oxygen Indicator Scores by Riverscape

Riverscape	Dissolved Oxygen Score
Riverscape 5	A
Riverscape 6	A
Riverscape 39	A
Riverscape 40	A
Riverscape 41	A
Riverscape 42	A
Riverscape 43	A
Riverscape 44	A
Riverscape 45	A
Riverscape 14	A
Riverscape 15	A
Riverscape 16	A

Figure 4-5. Dissolved Oxygen Concentrations from Quarterly Water Sampling at Three USGS Gauge Locations on the Yampa River (2010-2023)



4.3 pH INDICATOR

pH is a measure of water acidity that runs on a scale from 0 to 14, where lower numbers indicate high acidity, pH 7 is neutral, and higher numbers indicate water that is more basic. The ranges of many aquatic species are limited by pH. The pH of a water quality sample can be affected by biological activity in a stream, geology, precipitation, and human activities (Bauch et al. 2012).

4.3.1 Data Sources and Evaluation Methods

Field-based water quality parameters including pH are measured quarterly by USGS as part of the Upper Yampa River Basin Water Quality Monitoring Program. Three locations in the Steamboat segment are part of this monitoring program: Yampa River below Oak Creek; Yampa River at Steamboat Springs, CO; Yampa River at Milner, CO. Data were downloaded from nwis.waterdata.usgs.gov.

4.3.2 Scoring Criteria

Similar to temperature and dissolved oxygen, the scoring criteria for pH outlined in Table 4-7 are based on adherence to regulatory standards.

Table 4-7. pH Indicator Scoring Criteria

Grade	Description
A	pH values are natural and appropriate for a well-functioning river in its process domain.
B	pH values are within the range of natural variability. Natural aquatic biota may be minimally impaired. Regulatory standards are met.
C	pH is altered to a degree that could significantly affect natural aquatic biota. pH values occasionally fall outside the range of regulatory standards (6.5 - 9.0). CDPHE Monitoring and Evaluation (M&E) listed reaches fall in this category.
D	pH is altered to a degree that is known to affect natural aquatic biota. pH values frequently fall outside the range of regulatory standards (6.5 - 9.0). CDPHE 303(d) listed reaches fall in this category.
F	pH is fundamentally altered. Natural biota are severely impaired. pH values chronically fall outside the range of regulatory standards.

4.3.3 Results

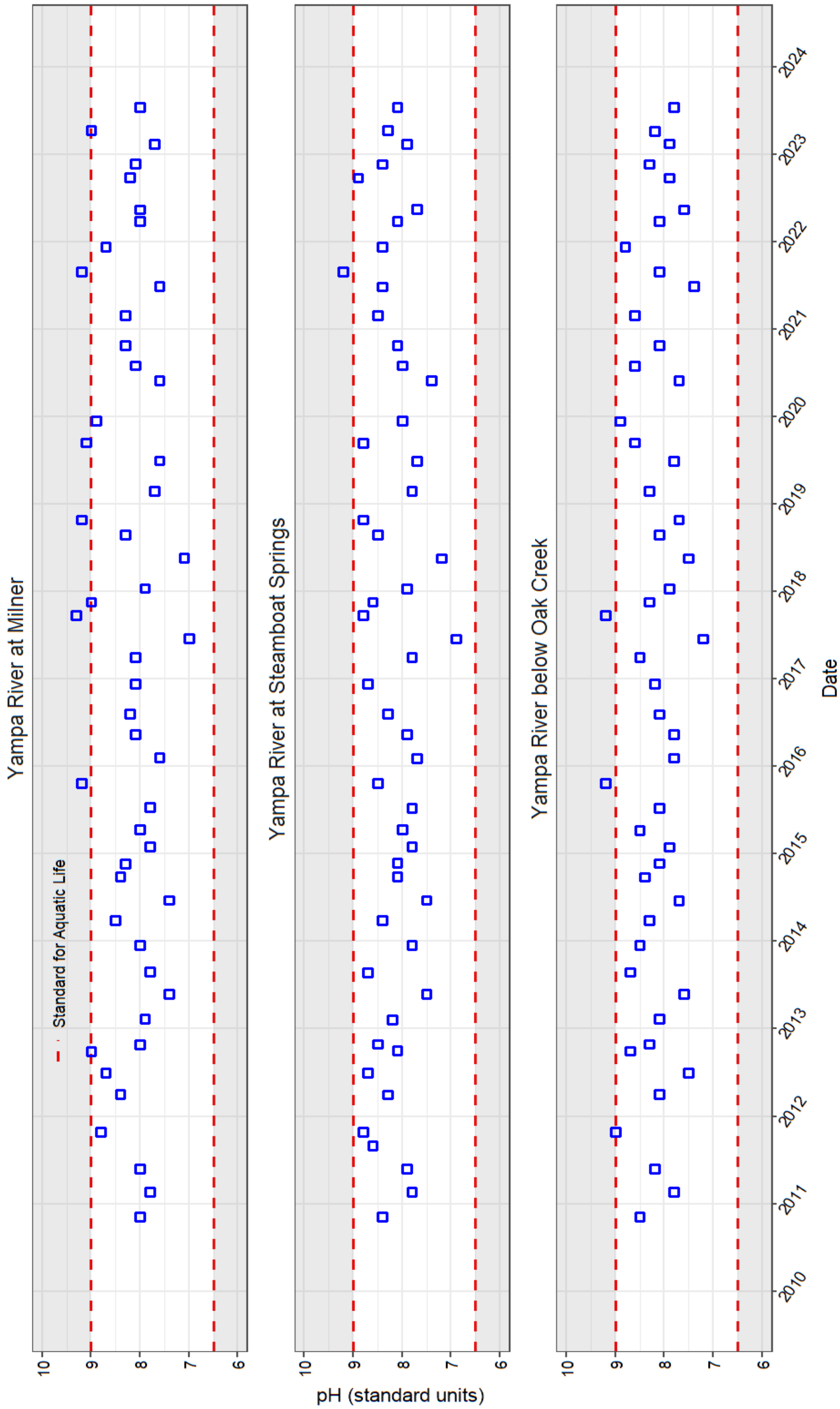
The pH indicator is evaluated through review of USGS Water Quality Monitoring Program data at the Yampa River below the Oak Creek confluence, and in the towns of Steamboat Springs and Milner, CO. Because rivers integrate upstream inputs, data from the Oak Creek station (located in riverscape 39) are used to score riverscapes 39, 6, and 5; data from the Steamboat station (located in riverscape 43) are used to score riverscapes 43, 42, 41, and 40; and the remaining riverscapes (16-14 and 45-44) are scored using the Milner station.

pH values less than 4 and greater than 10 can lead to mortality of aquatic life if the condition persists (Bauch et al. 2012). Values of pH across the Steamboat segment indicate neutral to slightly alkaline conditions. pH values exceed standards for aquatic life (6.5 - 9) multiple years at the Milner and Oak Creek Stations, and in summer 2021 at the Steamboat station. Between 2010-2022, pH is higher than regulatory standard eight times at the Milner station, predominantly in late summer, though the magnitude of exceedance is relatively minor. This is consistent with findings that pH values start to rise in the downstream direction as underlying lithology changes from majority metamorphic and igneous to predominantly sedimentary from Milner and below. The Oak Creek pH level is higher during three sampling periods in this same time frame. Although pH values in exceedance of 9 were detected once at Steamboat (Figure 4-6), regulatory standards are regularly and consistently met. Periodic exceedances of the upper limits of the regulatory pH range appear to be within the range of natural variability, and all exceedances are below 10. Riverscapes 43-40 earn an A score, while scores for the remaining riverscapes are slightly lower in accordance with the limited frequency and magnitude of regulatory exceedance (Table 4-8).

Table 4-8. pH Indicator Scores by Riverscape

Riverscape	pH Score
Riverscape 5	A-
Riverscape 6	A-
Riverscape 39	A-
Riverscape 40	A
Riverscape 41	A
Riverscape 42	A
Riverscape 43	A
Riverscape 44	B+
Riverscape 45	B+
Riverscape 14	B+
Riverscape 15	B+
Riverscape 16	B+

Figure 4-6. pH Values from Quarterly Water Sampling at Three Yampa River USGS Gauge Locations (2010-2023)



4.4 MACROINVERTEBRATES INDICATOR

Benthic macroinvertebrates are excellent indicators of the condition of lotic aquatic systems because macroinvertebrates are found in almost all freshwater environments, have a small home range, are relatively easy to sample and identify, and the different taxonomic groups show varying degrees of sensitivity to pollution and other stressors (CDPHE 2016a, Barbour et al. 1999). Benthic macroinvertebrate community monitoring is a useful tool for river health monitoring, particularly if baseline data are available.

Many comparative metrics may be used to assess the health of the benthic community, including the number of individuals; total number of taxa; total number of pollution-sensitive Ephemeroptera, Plecoptera, Trichoptera (EPT) taxa; percentage of EPT taxa; ratios of different functional feeding groups or taxonomic groups; Shannon-Wiener Diversity Index (SDI); Hilsenhoff Biotic Index (HBI); and many others. The SDI is a mathematical measure of species diversity within a given community. For benthic macroinvertebrates, values range from 0-5, and higher values indicate higher species diversity (MacArthur 1965). The HBI reveals the relative abundance of pollution-tolerant species. Scores range from 0-10, where a higher value indicates more pollution-tolerant species are present (Hilsenhoff 1987).

The Colorado Department of Public Health and Environment (CDPHE) monitors streams throughout the state for assessment and protection of water resource quality. Their principal indicator is a multi-metric index (MMI) based on direct benthic macroinvertebrate sample data. By using five to six equally weighted metrics, the MMI combines measures of diversity, abundance, pollution tolerance, community structure, and other factors to generate a normalized score of 0-100 for each sample. Scores may then be compared to reference threshold scores for one of three generalized Colorado biotypes (mountains, transition, plains). In “grey” areas where the MMI alone is not sufficient, CDPHE also compares SDI and HBI results to attainment and impairment threshold values.

4.4.1 Data Sources and Evaluation Methods

Historical benthic macroinvertebrate data are scarce for the Steamboat segment. Given the paucity of existing data, the relative ease of collecting and analyzing macroinvertebrate data, and the useful information that can be gleaned from these data, the Scorecard project provides a prime opportunity for evaluating the macroinvertebrate community and tracking changes over time.

Ten benthic macroinvertebrate community samples were collected in the Steamboat segment for the Scorecard project effort: two in riverscape 44, and one in each of the remaining riverscapes except riverscapes 42, 45, and 15. The macroinvertebrate community sample collected in riverscape 43 was at a riffle bordering riverscape 42, so that sample is used to score both riverscape 42 and 43. Similarly, the downstream sample collected in riverscape 44 was at a location in very close proximity to the border with riverscape 45, so that sample is used to score riverscape 45. Finally, because private property access was not available for riverscape 15, an average of the scores for riverscapes 14 and 16 were used. Macroinvertebrate monitoring occurred during the low-flow period in late August 2023, and followed the SOP used by CDPHE for benthic macroinvertebrate sampling (CDPHE 2016). Detailed procedures for sample collection, processing, and preservation are provided in the SOP. Samples were collected with partners from River Watch and sent to Timberline Aquatics for taxonomic identification and data analysis.

4.4.2 Scoring Criteria

The scoring criteria outlined in Table 4-9 are based on adherence to regulatory standards set by CDPHE for the relevant biotype (biotype 1, transition) using mainly MMI scores and CDPHE-designated attainment and impairment thresholds. Because component metrics incorporated into the MMI are designed to detect water quality impairments and are less sensitive to changes in habitat, results of other comparative metrics are also taken into account during the scoring process.

Table 4-9. Benthic Macroinvertebrate Indicator Scoring Criteria

Grade	Description
A	The reach is considered to be representative of the expected condition for aquatic insect communities and aquatic life use for a well-functioning river in its process domain. No management is needed other than protection of existing conditions. MMI score is 80-100 and the reach is in attainment for aquatic life use (CDPHE 2016).
B	Some detectable stressors are evident with minor alterations to aquatic insect communities. The ecological system retains its overall structure and supports a high level of function. Some management may be required to sustain or improve this condition. MMI score is in the 60-79 range, other metrics are generally indicative of a diverse and functional macroinvertebrate community, and the reach is in attainment for aquatic life use (CDPHE 2016).
C	The reach supports and maintains essential components of the unimpaired aquatic insect community, but exhibits measurable signs of degradation and less than optimal community parameters. Management is required (or recommended) to maintain and improve this condition. MMI score is in the 46-59 range and meets the CDPHE (2016) attainment threshold for aquatic life use, but other metrics are generally indicative of an impaired or unbalanced macroinvertebrate community.
D	Detectable alterations or degradation of aquatic life use are present, but the system still supports a fundamental aquatic insect community structure and function. Active management is required (or recommended) to maintain and improve characteristic functional support. MMI score is 34-45 and is considered to be in the "gray area" between aquatic life use attainment and impairment (CDPHE 2016).
F	Clear impairment to the aquatic insect community and aquatic life is present. This level of alteration generally results in an inability to support characteristic aquatic organisms, or makes the stream segment biologically unsuitable. MMI score is < 34 and aquatic life use is thus considered "impaired" (CDPHE 2016).

4.4.3 Results

The macroinvertebrates indicator is evaluated through analysis of data collected via the Scorecard project at benthic community monitoring locations within the Steamboat segment (Figure 4-7). All samples collected within the Steamboat segment exhibited moderately healthy to healthy macroinvertebrate communities. In particular, total taxa ranged between 31-50 taxonomic groups, percent of pollution-tolerant taxa was greater than 40% at all locations, species diversity scores were relatively high at all locations, and all locations exhibited a well-balanced array of functional feeding groups. In addition, MMI scores ranged from 55.8 to 76, well above the CDPHE aquatic life use "attainment" threshold of 46 for biotype 1 samples (Table 4-10, Figure 4-8). Interestingly, the riverscapes with some of the lowest MMI scores had some of the highest percentages of EPT taxa, while the riverscapes with some of the highest MMI scores had comparatively lower proportions of EPT species (Figure 4-9). These sites still support high numbers of sensitive taxa even though the diversity amongst these sensitive taxa is low. In general, Steamboat segment riverscapes received scores between B+ and C+ for the macroinvertebrate indicator (Table 4-11). While the riverscapes with lower scores are still in attainment of the aquatic life use per CDPHE guidelines, there is room for improvement for these benthic populations to become more robust and healthier in the future and opportunities for limited management, particularly related to grazing, to help improve conditions at these locations.

Figure 4-7. Macroinvertebrate Monitoring Locations

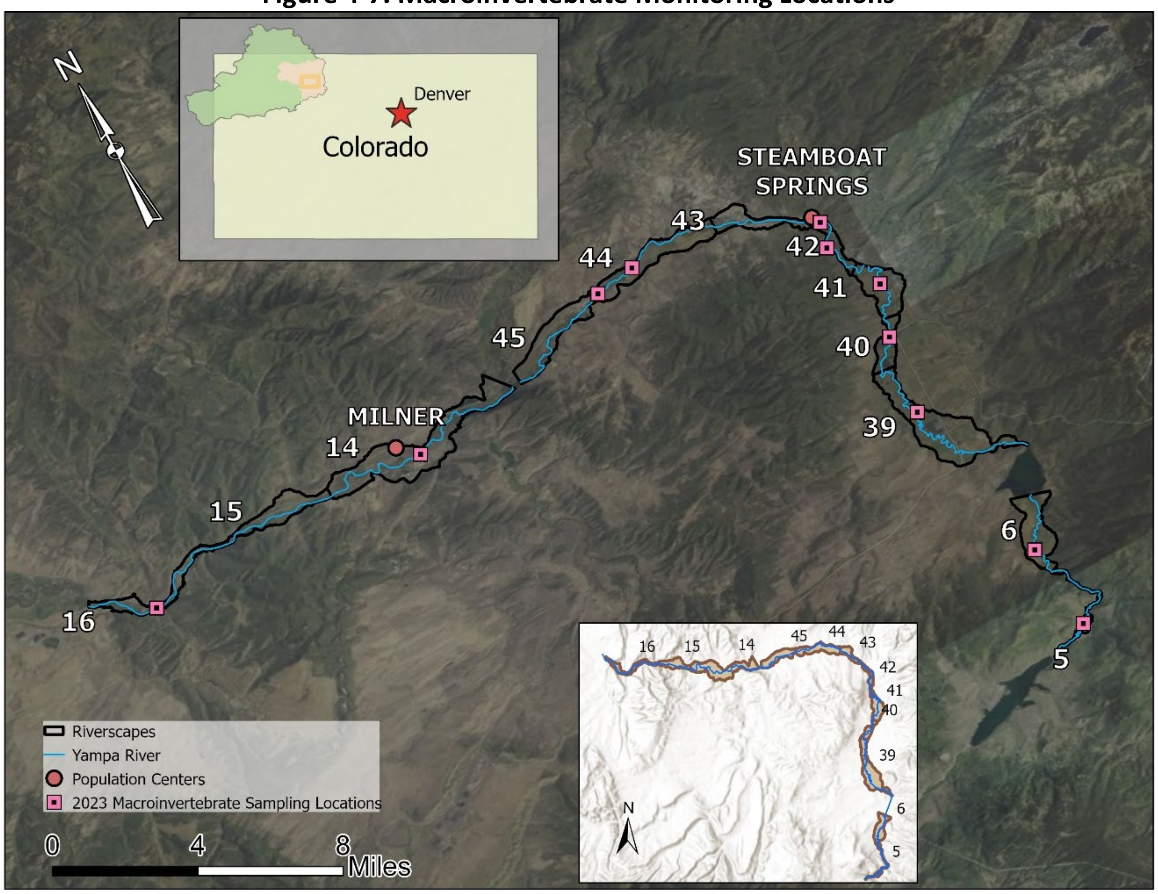


Table 4-10. Select Macroinvertebrate Metrics by Riverscape

Riverscape/ Metric	RS 5	RS 6	RS 39	RS 40	RS 41	RS 43 (42)	RS 44	RS 44 (45)	RS 14	RS 16
MMI v4	56.6	76.0	55.9	55.8	68.4	65.7	64.0	60.2	69.7	61.8
Diversity	3.42	4.22	3.35	3.12	3.35	3.69	3.66	3.34	3.81	3.30
Evenness	0.631	0.747	0.665	0.613	0.676	0.703	0.687	0.628	0.706	0.617
HBI	4.70	4.35	3.76	3.40	3.36	5.06	4.20	3.46	4.59	4.24
EPT	17	24	14	15	17	19	18	18	20	21
% EPT	62.7%	54.5%	78.1%	85.0%	64.0%	41.1%	70.7%	79.1%	58.5%	72.1%
Total Taxa	43	50	33	34	31	38	40	40	42	41
% Chironomids	24.6%	8.5%	4.9%	3.0%	4.4%	6.6%	11.5%	10.0%	17.9%	15.2%

Figure 4-8. Macroinvertebrate MMI Scores by Riverscape

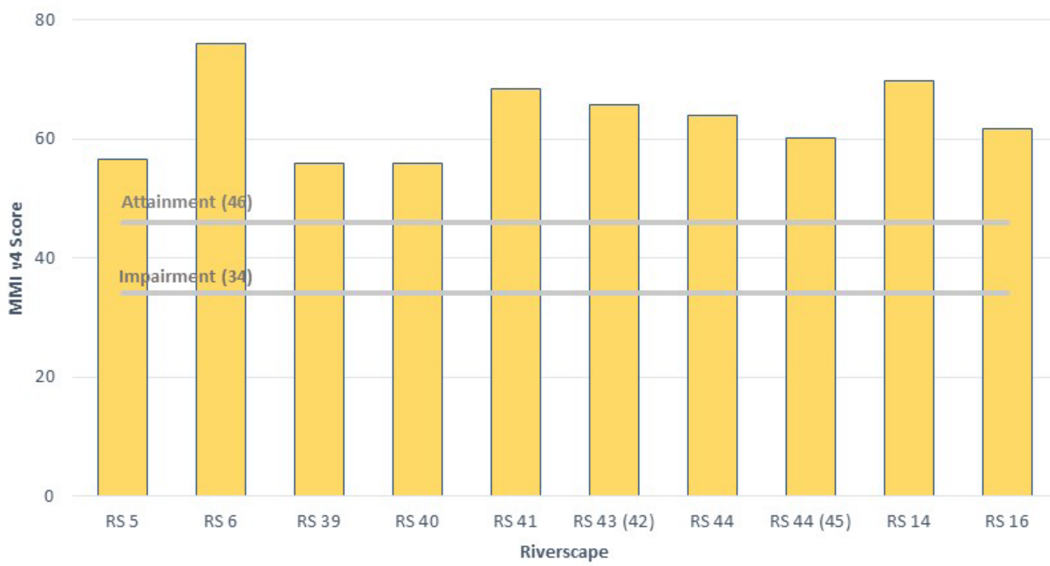


Figure 4-9. Macroinvertebrate Percent EPT Taxa by Riverscape

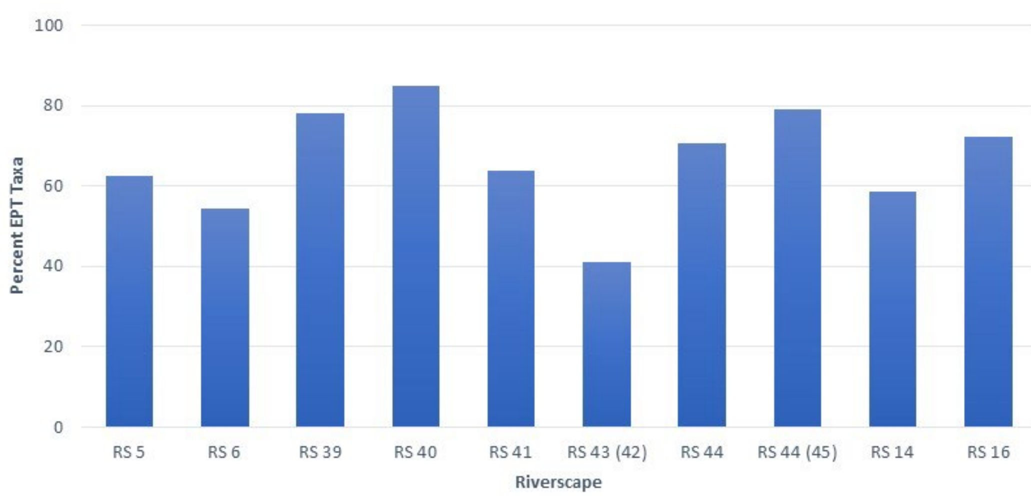


Table 4-11. Macroinvertebrate Indicator Scores by Riverscape

Riverscape	Macroinvertebrate Score
Riverscape 5	C+
Riverscape 6	B+
Riverscape 39	C+
Riverscape 40	C+
Riverscape 41	B+
Riverscape 42	B
Riverscape 43	B
Riverscape 44	B
Riverscape 45	B-
Riverscape 14	B+
Riverscape 15	B
Riverscape 16	B-

4.5 NUTRIENTS INDICATOR

Nutrients in stream water are essential for plants and animals. They occur naturally due to processes such as weathering and erosion, breakdown of organic material, and atmospheric deposition, but high nutrient levels are not good for stream health. Elevated nutrient levels in surface waters can result from human activities such as fertilizer application, runoff from agricultural and urban areas, effluent from wastewater treatment, seepage from septic systems, detergent, animal waste, and fuel combustion. Elevated nutrient levels can also cause algal blooms. In the last decade, concerns about cyanobacteria and associated cyanotoxins have been expressed by stakeholders in the Yampa Basin as algal blooms have been reported in local lakes and reservoirs, so this indicator is of public interest and therefore important to evaluate for the Scorecard.

4.5.1 Data Sources and Evaluation Methods

Nutrients, including total nitrogen and phosphorus, are measured quarterly by USGS as part of the Upper Yampa River Basin Water Quality Monitoring Program. Three locations in the Steamboat segment are part of this monitoring program: Yampa River below Oak Creek; Yampa River at Steamboat Springs, CO; Yampa River at Milner, CO. Data were downloaded from nwis.waterdata.usgs.gov.

4.5.2 Scoring Criteria

The scoring criteria outlined in Table 4-12 based on adherence to interim regulatory standards set by CDPHE for nitrogen and phosphorus are used to rate the nutrients indicator.

Table 4-12. Nutrients Indicator Scoring Criteria

Grade	Description
A	Nutrient levels are natural and appropriate for a well-functioning river in its process domain.
B	Nutrient levels are within the range of natural variability. Natural aquatic biota may be minimally impaired. Interim regulatory standards are not exceeded.
C	Nutrient levels are altered to a degree that could significantly affect natural aquatic biota. Interim regulatory standards (0.11 mg/L (cold) and 0.17 mg/L (warm) for total phosphorus; 1.25 mg/L (cold) and 2.01 mg/L (warm) for total nitrogen) are occasionally exceeded. CDPHE Monitoring and Evaluation (M&E) listed reaches fall in this category.
D	Nutrient levels are altered to a degree that is known to affect natural aquatic biota. Interim regulatory standards (0.11 mg/L (cold) and 0.17 mg/L (warm) for total phosphorus; 1.25 mg/L (cold) and 2.01 mg/L (warm) for total nitrogen) are frequently exceeded. CDPHE 303(d) listed reaches fall in this category.
F	Unnaturally eutrophic or oligotrophic conditions clearly affect the distribution and abundance of characteristic aquatic life. Interim regulatory standards have been exceeded consistently.

4.5.3 Results

The nutrients indicator is evaluated through review of USGS Water Quality Monitoring Program data at the Yampa River below Oak Creek, Yampa River at Steamboat Springs, CO, and Yampa River at Milner, CO, monitoring locations, where total phosphorus (TP), total Kjeldahl (organic) nitrogen (TKN), and total nitrogen T(N) have been measured quarterly since 2010. Because rivers integrate upstream inputs, data from the Oak Creek station (located in riverscape 39) are used to score riverscapes 39, 6, and 5; data from the Steamboat (located in riverscape 43) are used to score riverscapes 43, 42, 41, and 40; and the remaining riverscapes (16-14 and 45-44) are scored using the Milner station. A USGS analysis of nutrient data (both concentrations and loads) in the Upper Yampa Basin for the 1992-2018 period was completed in 2021; more specifically, this report analyzed nutrient data at the below Oak Creek and Milner stations from 2010-2018, and from 1999-2018 at the Steamboat location. Scoring is based upon that analysis, the findings of which have been synthesized for the purpose of the Scorecard and are presented below (Day 2021), as well as additional examination of the data subsequent to the period covered in the USGS report (2019-2023). Details of the methodology used in the nutrient analysis that yielded the summarized results below can be found in the body of the referenced USGS report (Day 2021).

Total nitrogen (inorganic + organic nitrogen; TN) is measured quarterly by USGS at the sites mentioned above, as is Kjeldahl nitrogen (TKN). In the USGS report, daily concentrations of constituents are estimated from quarterly samples using linear regression models fit with R-LOADEST, a USGS-developed statistical program designed to calculate nutrient loads from periodic sampling data (see equation 1 of Day [2021] for mathematical explanation). Daily estimations of TN are not able to be made due to lack of the requisite number of samples; therefore, daily estimations of TKN are used as a surrogate for TN. Notably, daily estimations do not include quarterly sampling data from 2019-2023; rather, only the discrete data for this latter period were analyzed for the purposes of the Scorecard.

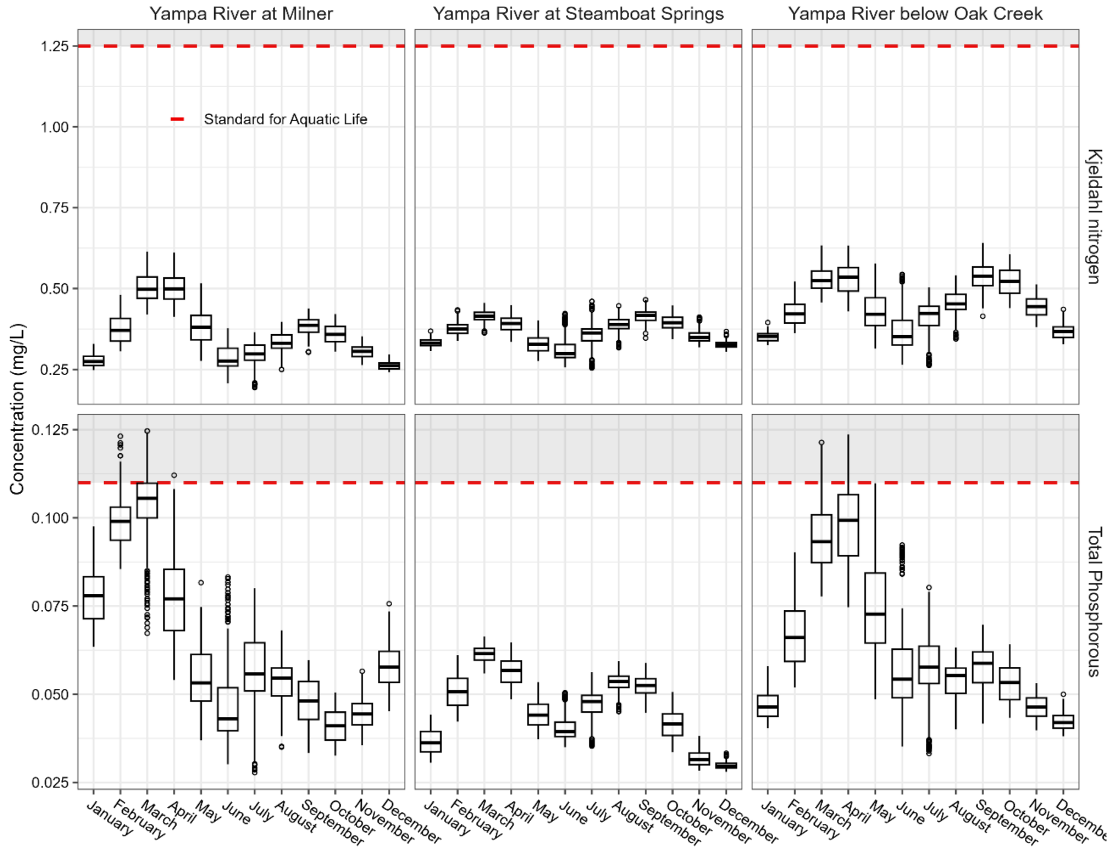
Estimated median annual TKN was well below the interim regulatory standard of 1.25 mg/L for cold water rivers for all evaluated water years and at all gauging stations in the focal segment, although below Oak Creek had the highest median concentrations (Table 4-13, Figure 4-10). Closer examination at a finer scale paints a similar picture: modeled daily and monthly median concentrations for TKN were also well below the regulatory standard for all days across the analysis period at each site (Figure 4-10). Day (2021) notes that model outputs for two stations within this focal segment, below Oak Creek and Steamboat, did have adjusted R^2 values below 0.5, possibly indicating that additional information is needed to improve predictions. Despite the model's shortfalls, when discrete values are investigated, TKN concentrations remained well below the interim regulatory standard at all sites. Discrete TN concentrations (Figure 4-11) similarly remained below the interim regulatory standard for all quarterly samples, with some concentrations falling below the method detection limit (see Day 2021 for more details). In general, Day (2021) found an overall trend of increasing concentrations in the downstream direction with the highest overall concentrations during spring runoff, below Milner, CO near Elkhead Creek (outside of the Steamboat segment). All riverscapes score an A with respect to nitrogen.

Table 4-13. Modeled Median Kjeldahl Nitrogen and Total Phosphorous Concentrations for Each Water Year and the Overall Period of Analysis, 2010-2018 (adapted from Day [2021])

Station	2010	2011	2012	2013	2014	2015	2016	2017	2018	2010-18
Modeled Median Kjeldahl Nitrogen concentration (mg/L)										
Yampa River below Oak Creek	0.42	0.41	0.48	0.46	0.42	0.42	0.44	0.45	0.47	0.45
Yampa River at Steamboat Springs	0.37	0.35	0.38	0.37	0.35	0.35	0.36	0.38	0.38	0.36
Yampa River at Milner	0.32	0.32	0.36	0.35	0.31	0.33	0.33	0.34	0.35	0.34
Modeled Median Total Phosphorous Concentration (mg/L)										
Yampa River below Oak Creek	0.055	0.049	0.061	0.058	0.050	0.056	0.058	0.058	0.063	0.057
Yampa River at Steamboat Springs	0.046	0.043	0.048	0.047	0.044	0.044	0.045	0.046	0.047	0.046
Yampa River at Milner	0.048	0.046	0.063	0.061	0.050	0.054	0.057	0.056	0.064	0.056

Note: All years are water year (October-September) rather than calendar year

Figure 4-10. Modeled Monthly Median Kjeldahl Nitrogen and Total Phosphorus at Three USGS Gauging Stations from 2010-2018 (Adapted from Day [2021])



Like nitrogen, total phosphorous (TP) is measured quarterly at each station in the study area, and these quarterly samples were used to estimate daily TP concentrations. Estimated median annual total phosphorous (TP) was below the interim regulatory standard of 0.11 mg/L for cold water rivers at all sites and all years (Table 4-13, Figure 4-8). Again, the below Oak Creek station had the highest estimated median, but only marginally. However, summarizing the data at the annual scale obscures some trends; at closer examination, estimated daily concentrations exceeded the standard occasionally during the late winter and early spring months at both Milner and below Oak Creek stations, but not at the Steamboat station. Median monthly values of TP for the period analyzed exceed the interim regulatory standard February through April at Milner and March to April below Oak Creek (Figure 4-8). Additional information is provided by examining the modeled data at the daily scale. For the Milner station, median number of days over the period of record in which the interim water quality standard is exceeded are 13, 11, and 1 days for February, March, and April, respectively. Median number of days exceeded over the period of record below the Oak Creek station are 5 for the month of March and 4 for the month of April. Again, Steamboat station modeled estimates showed no exceedances. Day (2021) noted that these three Steamboat segment stations had the lowest R^2 values (<0.5) of all sites, like TKN modeling, and that additional covariates, such as continuous measurements of suspended sediment, could help strengthen the model (Day 2021).

Despite the model limitations, discrete phosphorous concentrations also showed exceedances of the interim regulatory standard occasionally during the late winter and early spring months between 2010 and 2023; however, exceedances occurred at all three sites, not excluding the Steamboat station. At the Steamboat station, two exceedances of TP in discrete samples greater than 0.11 mg/L were measured during May 2016 and March 2017 (Figure 4-9). One measured exceedance each occurred at the Oak Creek and Milner stations in May 2016 and February 2013, respectively. Given the infrequent exceedance of interim regulatory standards and uncertainty of modeled predictions, the Milner and Oak Creek riverscapes each receive A scores regarding TP and Steamboat riverscapes each receive a score of A- to reflect slightly more frequent measured occurrences. Combined nutrient indicator scores are provided in Table 4-14.

Figure 4-11. Measured (Discrete) Kjeldahl Nitrogen, Total Nitrogen, and Total Phosphorus Values at Three USGS Gauging Stations (2010-2023)

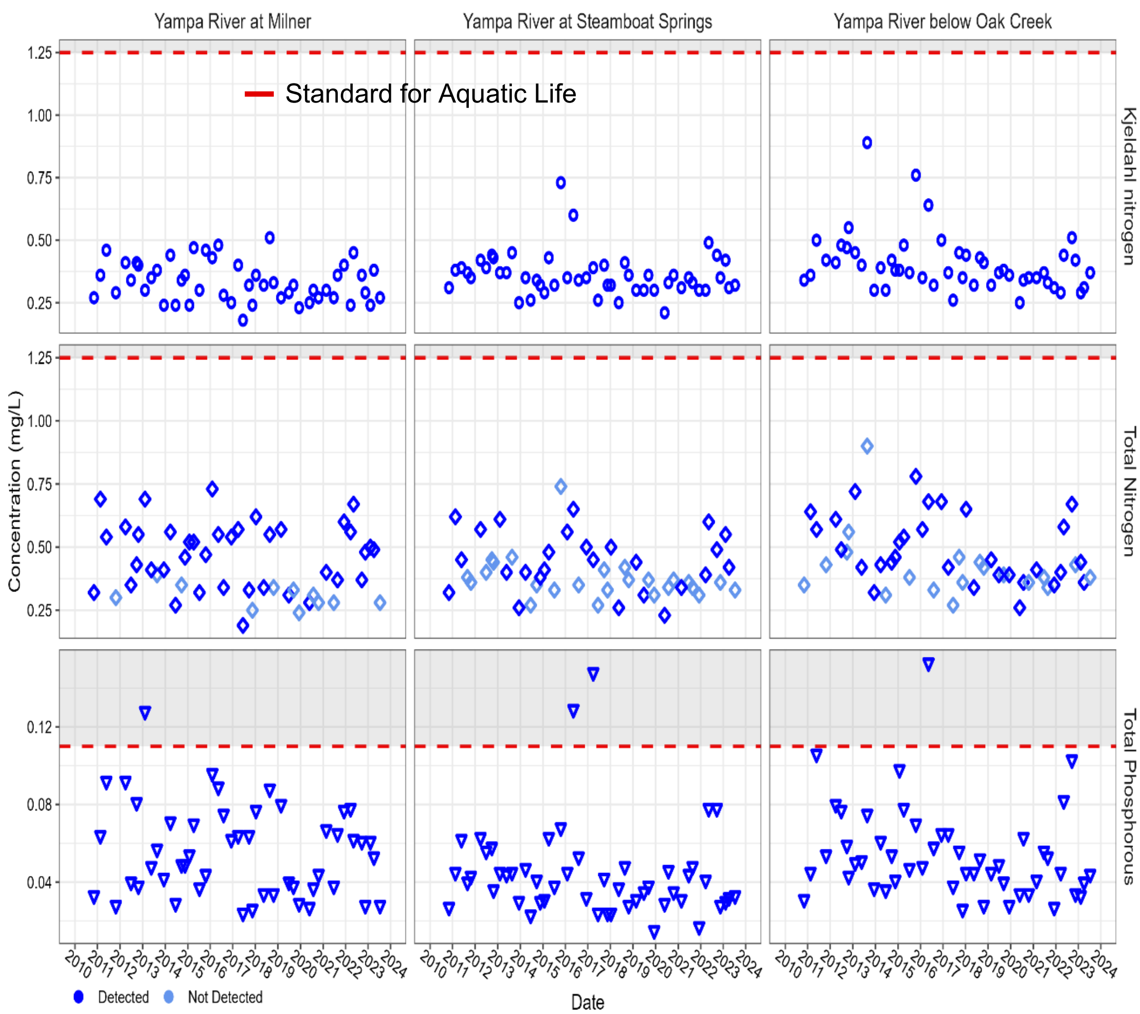


Table 4-14. Nutrients Indicator Scores by Riverscape

Riverscape	Nitrogen Score	Phosphorus Score	Nutrients Score
Riverscape 5	A	A	A
Riverscape 6	A	A	A

Riverscape 39	A	A	A
Riverscape 40	A	A-	A
Riverscape 41	A	A-	A
Riverscape 42	A	A-	A
Riverscape 43	A	A-	A
Riverscape 44	A	A	A
Riverscape 45	A	A	A
Riverscape 14	A	A	A
Riverscape 15	A	A	A
Riverscape 16	A	A	A

4.6 METALS INDICATOR

Metals generally occur at low concentrations in surface waters, and a number of them are essential nutrients to aquatic biota, but they are toxic at higher concentrations. CDPHE sets regulatory standards for most metals based on the uses identified for each stream segment (e.g., water supply, agriculture, recreation, aquatic life protection); if water quality samples frequently exceed these standards, the stream segment is placed on the State's 303(d) or M&E (monitoring and evaluation) list for that particular constituent.

4.6.1 Data Sources and Evaluation Methods

Select trace metals (total iron and manganese; dissolved cadmium, copper, lead, manganese, selenium, silver, and zinc) are measured quarterly by USGS as part of the Upper Yampa River Basin Water Quality Monitoring Program. Three locations in the Steamboat Scorecard focal segment are part of this monitoring program: Yampa River below Oak Creek; Yampa River at Steamboat Springs, CO; Yampa River at Milner, CO. Data were downloaded from nwis.waterdata.usgs.gov.

4.6.2 Scoring Criteria

The scoring criteria outlined in Table 4-15 based on adherence to regulatory standards set by CDPHE are used to rate the metals indicator.

Table 4-15. Metals Indicator Scoring Criteria

Grade	Description
A	Chemical conditions are within ranges that are natural and appropriate for a well-functioning river in its process domain.
B	Chemical conditions are within the range of natural variability. Natural aquatic biota may be minimally impaired even though background concentrations of

	certain metals may be elevated. Regulatory standards are not exceeded (except for metals with elevated background concentrations).
C	Chemical conditions are altered to a degree that could potentially limit natural aquatic biota. Stressors are present which create conditions that may warrant inclusion on State impaired waters lists. CDPHE Monitoring and Evaluation (M&E) listed reaches fall in this category.
D	Chemical conditions are altered to a degree that is known to be lethal or limiting to natural aquatic biota. Regulatory standards are frequently exceeded. CDPHE 303(d) listed reaches fall in this category.
F	The chemical environment is fundamentally altered. Natural biota are severely impaired. Regulatory standards have been exceeded consistently.

4.6.3 Results

The metals indicator is evaluated through review of USGS Water Quality Monitoring Program data at the Yampa River below Oak Creek, Yampa River at Steamboat Springs, CO, and Yampa River at Milner, CO, monitoring locations, where total iron, total and dissolved manganese, dissolved cadmium, dissolved copper, dissolved lead, dissolved selenium, dissolved silver, and dissolved zinc are measured quarterly. As was done with other water quality indicators, because rivers integrate upstream inputs, data from the Oak Creek station (located in riverscape 39) are used to score riverscapes 39, 6, and 5; data from the Steamboat (located in riverscape 43) are used to score riverscapes 43, 42, 41, and 40; and the remaining riverscapes (16-14 and 45-44) are scored using the Milner station. A USGS analysis of metals and other water quality data for the Upper Yampa Basin for the 1979-2009 period was completed in 2012; portions of this report that contain analysis and interpretation of data for the Steamboat focal segment were examined for additional context (Bauch et al. 2012).

Of the metal constituents analyzed, all except iron were consistently below CDPHE regulatory standards at all three monitoring locations (though the detection limit of the method used to calculate silver concentrations post-2015 precludes stating this with certainty) (Figure 4-12). Similar findings were discovered in analysis of samples from 1979-2009 (with samples from above Chuck Lewis Colorado Parks and Wildlife (CPW) park (Bauch et al. 2012). In the figure, open circles indicate that concentration was below the level of the position of the point (e.g., an open circle at 1 mg/L for silver suggests that silver concentration for that sample was < 1 mg/L). Red shading indicates acute contamination standard; yellow is chronic; green is acceptable the range for aquatic life. Elevated iron levels are likely lithologically driven; the sedimentary and igneous rocks in the Yampa Basin contain iron and iron-bearing minerals in relatively high concentrations (Bauch et al. 2012). Likely because of the high natural iron content in the surrounding rocks and because of the relatively few exceedances of the regulatory standard, the CDPHE monitoring sections of the Yampa River contained within the Steamboat segment riverscapes are not listed as M&E or 303(d) for metals. Overall, the relatively low concentrations of metals in the riverscapes considered tracks with the recent cessation or overall lack of activities that generally enhance in-stream concentrations of metallic species (e.g., industrial production, mining of precious metals). Every riverscape therefore scores an A for the metals indicator (Table 4-16).

Figure 4-12. Total (Iron) and Dissolved Metals Concentrations from Quarterly Water Sampling at Three USGS Gauge Locations on the Yampa River (2010-2023)

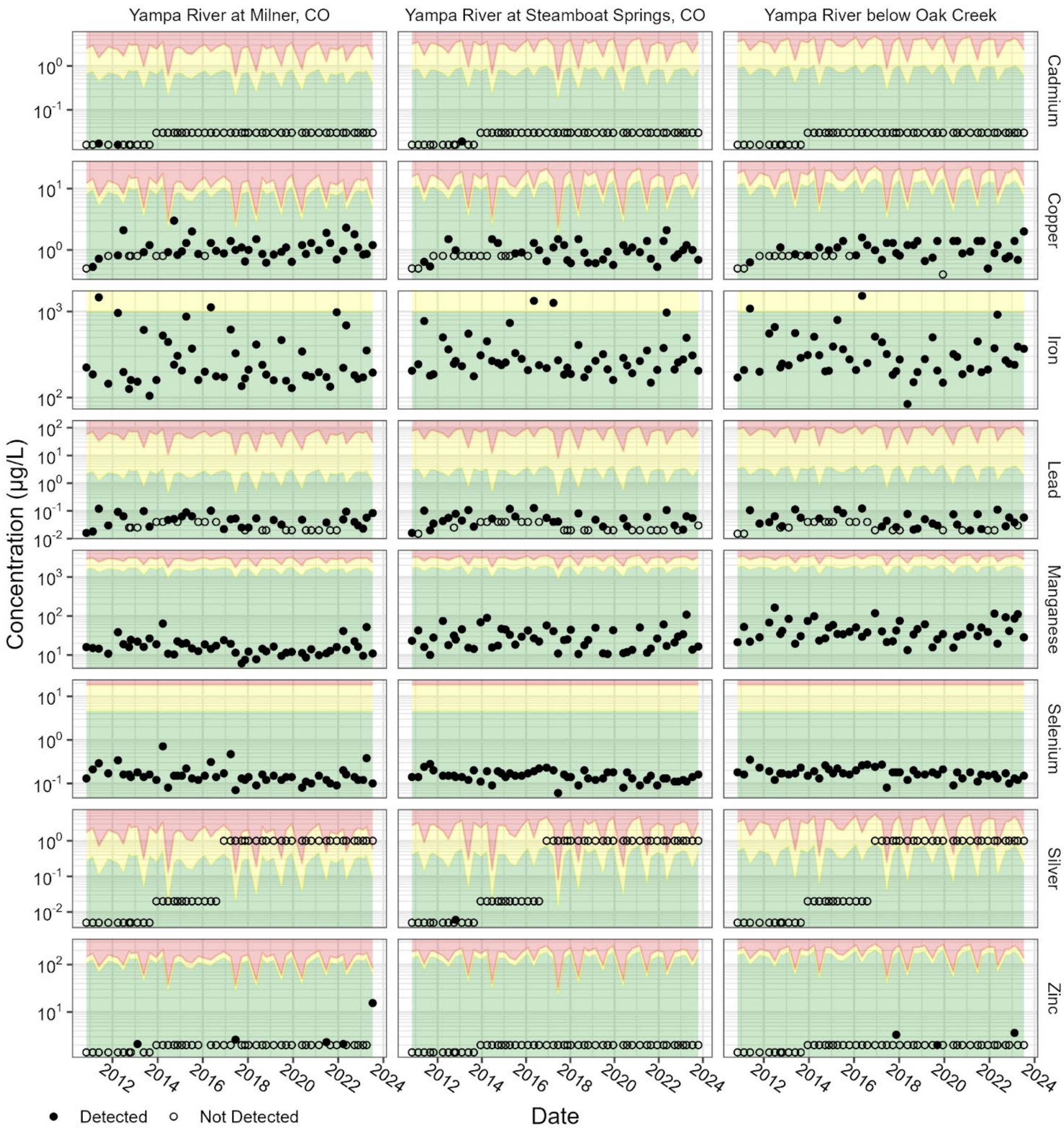


Table 4-16. Metals Indicator Scores by Riverscape

Riverscape	Metals Score
Riverscape 5	A
Riverscape 6	A
Riverscape 39	A
Riverscape 40	A
Riverscape 41	A
Riverscape 42	A
Riverscape 43	A
Riverscape 44	A
Riverscape 45	A
Riverscape 14	A
Riverscape 15	A
Riverscape 16	A

5.0 HABITAT CONNECTIVITY

Habitat connectivity is defined as the interaction and interconnectedness between a river segment and its surrounding landscape, including pathways for movement of biological organisms and organic matter through the riparian corridor. This category includes connectivity of both terrestrial and aquatic communities and considers both longitudinal (upstream/downstream) and lateral (channel/floodplain/upland) directions. The Yampa River Scorecard evaluates two indicators within the habitat connectivity category: **aquatic connectivity** and **terrestrial connectivity**. The final habitat connectivity score is calculated as an average of the aquatic connectivity and terrestrial connectivity indicator scores.

5.1 AQUATIC CONNECTIVITY INDICATOR

The aquatic connectivity indicator addresses the ability for aquatic organisms to migrate and disperse in both longitudinal (upstream/downstream) and lateral (between the channel and floodplain, e.g., side channels) directions. This indicator looks at the presence or absence of barriers to aquatic movement.

5.1.1 Data Sources and Evaluation Methods

Data used to score this indicator are collected by floating or hiking the entire focal segment of the Yampa River and identifying (and marking with GPS) any in-channel structures and barriers to aquatic species movement. This fieldwork was completed mid-June and late July 2023 coordinated in partnership with Colorado Mountain College and local landowners (Appendix A). To the extent possible, observers assessed the height of channel spanning structures and the amount of time of the year and associated flow conditions where that structure poses a barrier to aquatic species movement (e.g., only passable during spring runoff, impassable during all flow conditions, etc.). Other in-channel structures, such as cross-vanes, weirs, and boulder features were also noted.

Field floats and hikes also identify the following features that are important to aquatic species migrating laterally for spawning and cover:

- Permanently inundated side channels;
- Seasonally inundated side channels;
- Backwater areas; and
- Split flows (i.e., two narrow channels versus one wide channel).

Fieldwork is augmented by review of historical aerial imagery to reflect the complexity and evolution of the riverscapes in terms of aquatic connectivity.

5.1.2 Scoring Criteria

The scoring criteria outlined in Table 5-1 based on presence and extent of barriers to aquatic species movement are used to rate the aquatic habitat connectivity indicator.

Table 5-1. Aquatic Habitat Connectivity Indicator Scoring Criteria

Grade	Description
A	No significant barriers exist that prevent migration or dispersal of aquatic organisms within the entire ecoregion and upstream headwaters.
B	Impermeable migration/dispersal barriers are at least 10 miles apart and/or there are minor migration/dispersal impediments on the reach or adjacent reaches. Mild loss of side channel and/or backwater area access may impact spawning and cover for certain species.
C	Impermeable migration/dispersal barriers are approximately 5 miles apart and/or there are multiple migration/dispersal impediments on the reach or adjacent reaches. Moderate loss of side channel and/or backwater area access may impact spawning and cover for certain species.
D	Impermeable migration/dispersal barriers are approximately 2 miles apart and/or migration/dispersal is severely impeded on the reach or adjacent reaches. Substantial loss of side channel and/or backwater area access may impact spawning and cover for certain species.
F	The reach is effectively isolated. Impermeable migration/dispersal barriers are approximately 1 mile apart or less and/or migration/dispersal is completely impeded on the reach or adjacent reaches. Access to side channel and/or backwater areas for spawning and cover is unavailable.

5.1.3 Results

The results of aquatic connectivity scoring are composed of two parts that together yield an overall score for this indicator: barriers to longitudinal connectivity (e.g., dams) and pathways for lateral connectivity (e.g., side channels).

In assessing aquatic connectivity, the Yampa River reveals a nuanced spectrum of obstructions to longitudinal connectivity. Unlike some rivers in the Colorado River Basin, the Yampa experiences minimal in-channel barriers to longitudinal connectivity. The existing channel-spanning barriers, such as 'push-up' dams, weirs, and rock structures, present a range of challenges. The Middle Yampa segment was observed to have many large, concerning barriers to aquatic migration near population centers (e.g., Hayden and Craig). Unlike the Middle Yampa segment, the channel-spanning structures found in the Steamboat segment pose minimal impacts on aquatic species migration due to differences in size, material, and condition. Many of the Steamboat segment impediments are shorter and remain passable through all times of the year (Appendix A, Photos A-9 through A-12 and Photo A-32). However, the prevalence of partially spanning features, such as cross-vane rock structures, is notable, especially within the City of Steamboat Springs. These structures, primarily intended for bank stabilization/protection, flow redirection, and recreational fun, do not significantly hinder aquatic organism passage, but do interrupt natural sediment, flood, and habitat development processes (Appendix A, Photos A-12 and A-34). Despite the lack of longitudinal barriers in the Steamboat segment, this technical synthesis explores the range of impediments, emphasizing their composition, distribution, and implications for aquatic connectivity in the Yampa River.

Channel-spanning structures are relatively dispersed throughout the study reaches, but are comparatively lacking in the riverscapes downstream of the City of Steamboat Springs (riverscapes 45, 14, 15, and 16; Figure 5-1). The middle riverscapes through the City (riverscapes 40-43) contain the most frequent instances of channel-spanning features in close proximity to each other, though these features are kayaking waves made of rock placed by the City to encourage recreation and increase bank stabilization and do not pose a migration barrier for aquatic organisms (Figure 5-1). Distances between structures and concentrations of channel-spanning structures are within a moderate range in the remaining riverscapes (riverscapes 39, 44, and 5-6) due to greater irrigation and diversion demands and management, as well as the concrete stilling basin constructed below Stagecoach Reservoir to protect the river from impacts of dam operations. While the composition of channel-spanning structures varies (e.g., concrete versus boulders), their impact on the migration of aquatic species throughout the year is generally minimal, as assessed during low-flow conditions in late summer. This assessment was based on visual observations of the structures, which were often short, partially breached, or situated in locations with additional channels available for migration (note that the heights of these structures were not directly measured, but rather estimated visually during this period). The limited number of channel-spanning features is offset by the larger number of partially spanning features, however (Figure 5-2). Partial spanning features, typically in the form of cross-vane rock structures or boulders placed mid-channel, occur in great quantity throughout most of the Steamboat segment (Appendix A, Photos A-9, A-10, and A-14). Many of these are intended to direct flow and do not pose aquatic organism passage concerns, but do interrupt natural sediment, flood, and habitat development processes. The highest concentrations of partial spanning structures are found, unsurprisingly, throughout the reaches within the City of Steamboat Springs, and in the upper reaches associated with bank stabilization restoration work. Scores for the aquatic barriers score can be found in Table 5-2.

Figure 5-1. In-Channel Barriers to Longitudinal Movement as Observed in the Field

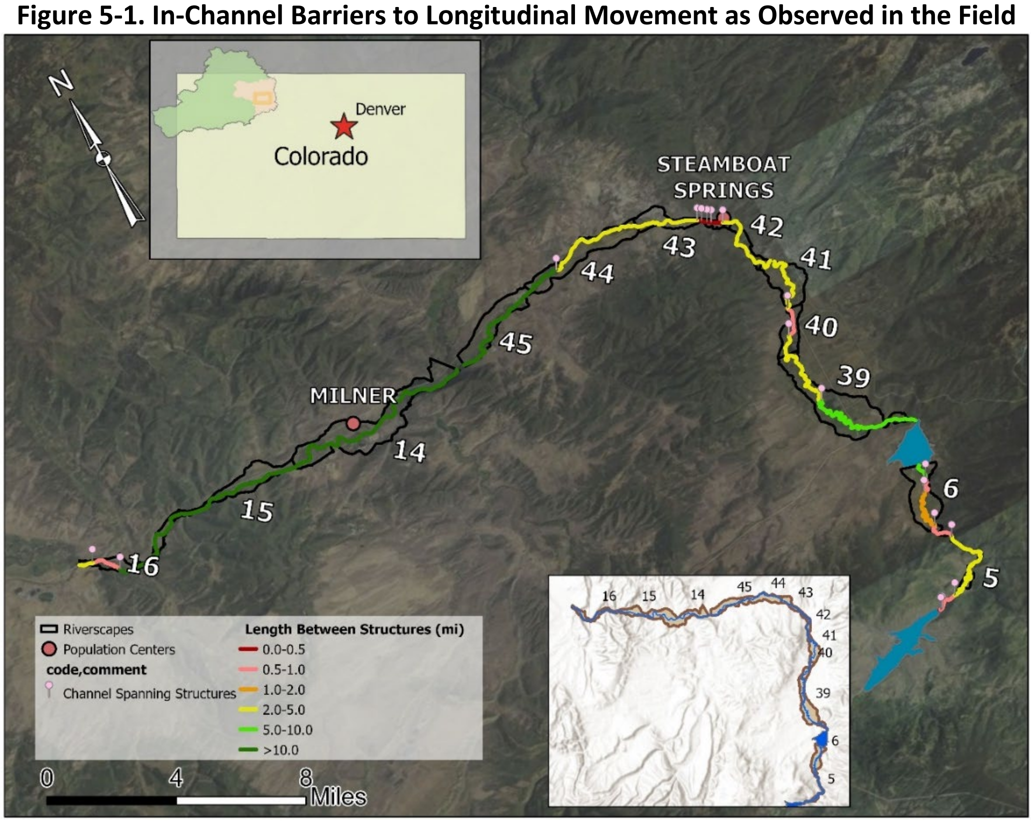
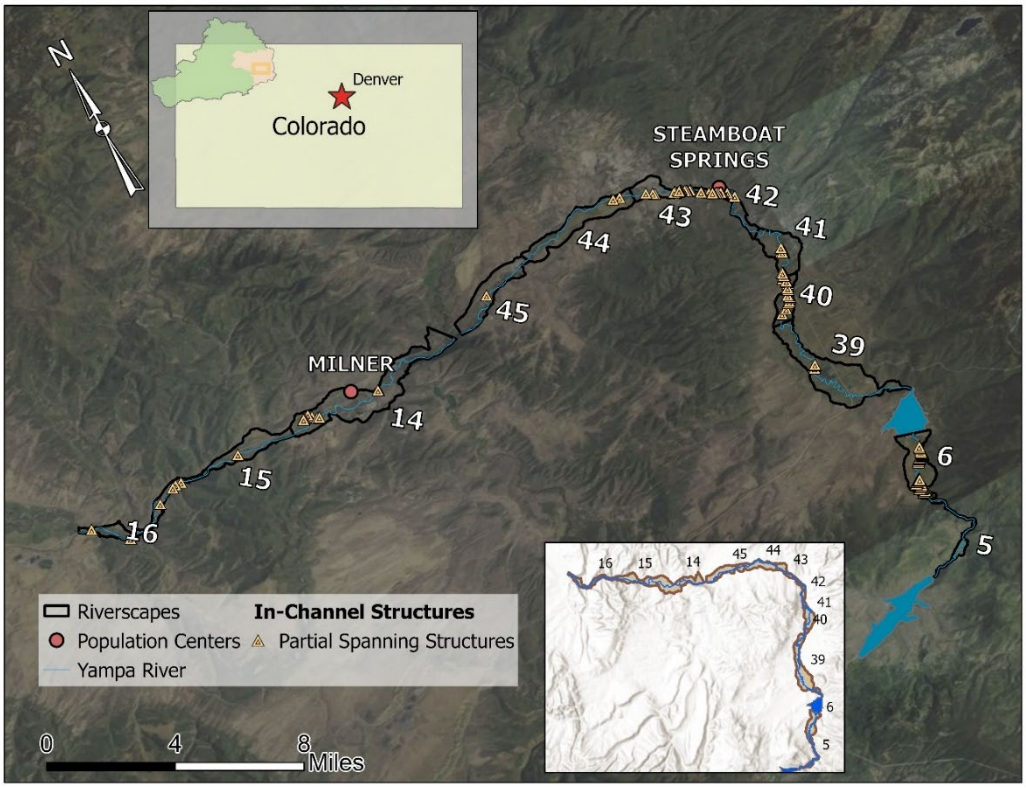


Figure 5-2. Partial Impediments to Longitudinal Movement as Observed in the Field



Pathways for lateral movement (e.g., side channels) are commonly found along the Yampa throughout the study area. The presence of such features enables aquatic organisms to extricate themselves from the higher energy of the main channel into relatively sheltered and quiescent waters (Appendix A, Photos A-25, A-36, A-35, and A-36). Lateral connectivity pathways are important for spawning and rearing of several species of fish, as well as for other organisms that may move frequently between the main river channel and the neighboring floodplain (e.g., beaver). Lateral pathways scores were determined by (1) calculating the number of such features observed in the field and on imagery per river mile, and then (2) evaluating that number relative to what may be expected of a natural river in its process domain using the following rubric, which dovetails with the scoring criteria described in Section 5.1.2: No loss of side channel access (>4/mile); mild loss of side channel access (<4/mile); moderate loss of side channel access (<3/mile); substantial loss of side channel access (<2/mile); and full loss of side channel access (<1/mile).

Lateral pathways were most frequent and widespread in riverscapes 41, 44, and 45, and, only slightly less concentrated in riverscapes 14-16 (Figure 5-3). The areas with the highest concentration of lateral pathways are generally in direct correlation with a lack of in-channel structures and higher floodplain connectivity scores (see Section 6.1). Inspection of aerial imagery suggest that high scores may be a function of the presence of substantial portions of intact riparian forest, greater floodplain access, and higher concentrations of woody material (see Section 9.1 and Appendix A, Photos A-17 and A-18) along these riverscapes, emphasizing the benefits of preserving such floodplain ecosystems for the river. Surprisingly, this correlation is true even in riverscapes with lower floodplain connectivity scores. Riverscape 6 earns a lower score for the presence of lateral pathways mainly due to bank stabilization restoration efforts.

Riverscape 5 also scores low; however, this reach's confinement naturally limits development of lateral mobility. Despite the presence of island features, true secondary habitat is severely lacking in most reaches within riverscape 5. Scores for lateral mobility are presented in Table 5-2.

Figure 5-3. Locations of Pathways for Lateral Movement as Observed in the Field

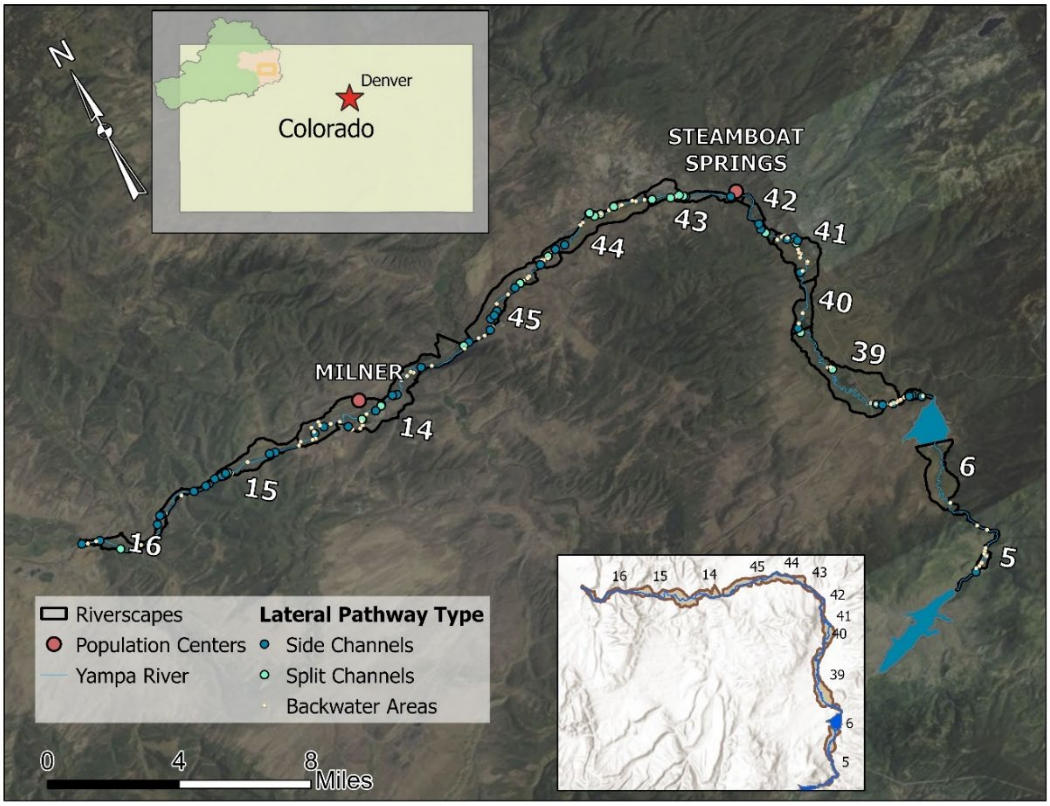


Table 5-2. Aquatic Connectivity Indicator Scores by Riverscape

Riverscape	Barriers Score	Lateral Pathways Score	Aquatic Connectivity Score
Riverscape 5	B	C	C+
Riverscape 6	B-	D	C-
Riverscape 39	A-	B	B+
Riverscape 40	B	C	C+
Riverscape 41	A	A	A
Riverscape 42	A	C+	B
Riverscape 43	B-	B-	B-
Riverscape 44	A	A-	A
Riverscape 45	A	A-	A

Riverscape 14	A	B+	A-
Riverscape 15	A	B+	A-
Riverscape 16	A-	B+	A-

5.2 TERRESTRIAL CONNECTIVITY INDICATOR

The terrestrial connectivity indicator addresses the ability of terrestrial organisms to move both longitudinally (upstream/downstream) and laterally (between the channel and riparian zone, between riparian zone and upland areas). This indicator considers habitat fragmentation, including barriers created by roads, railroads, trails, bridges, fences, and other impediments.

5.2.1 Data Sources and Evaluation Methods

The Scorecard relies on floodplain fragmentation metric results from the Yampa IWMP remote assessment that was conducted as part of the riparian condition evaluation (Yampa IWMP 2021). For context, the Yampa IWMP remote assessment evaluated riparian condition across the basin using the Riparian Condition Assessment Tool (RCAT) developed by Utah State University (MacFarlane et al. 2018). RCAT provides a holistic proxy measure of riparian condition by assessing and integrating three key metrics of riparian functions: (1) riparian vegetation departure from historical conditions, (2) land use intensity within valley bottoms, and (3) floodplain fragmentation by infrastructure (roads, railroads, levees, etc.). The floodplain fragmentation metric calculates the proportion of accessible versus inaccessible floodplain within a reach due to roads, railroads, levees, or other infrastructure. Scores range from one (fully accessible) to zero (inaccessible). The floodplain fragmentation statistic calculated for each riverscape (encompassing the lateral extent of the entire valley bottom) is coupled with review of aerial imagery to rate the terrestrial connectivity indicator. For consistency, riverscapes not included in the geographic scope of the Yampa IWMP were evaluated in 2023 using the same methodology.

5.2.2 Scoring Criteria

The terrestrial connectivity indicator scoring criteria outlined in Table 5-3 are based on floodplain fragmentation and severity and proximity of migration barriers to terrestrial species movement.

Table 5-3. Terrestrial Connectivity Indicator Scoring Criteria

Grade	Description
A	Negligible fragmentation of the floodplain by infrastructure and development, with a floodplain fragmentation score of > 91%. No significant barriers to migration or dispersal of terrestrial organisms.
B	Minor fragmentation of the floodplain by infrastructure and development, with a floodplain fragmentation score between 71-90%. Impermeable barriers affect a minor portion of surrounding habitat, but permeable barriers such as gravel roads, minor berms, ditches, or barbed wire fences may be present.
C	Moderate fragmentation of the floodplain by infrastructure and development, with a floodplain fragmentation score between 41-70%. Impermeable barriers affect a moderate portion of surrounding habitat, and semi-permeable barriers

	such as two-lane paved roads, rail lines, or widely scattered residential development may be present.
D	Significant fragmentation of the floodplain by infrastructure and development, with a floodplain fragmentation score between 21-40%. Impermeable barriers and/or permeable barriers affect a substantial portion of surrounding habitat.
F	Severe fragmentation of the floodplain by infrastructure and development, with a floodplain fragmentation score of < 20%. Impermeable barriers and/or permeable barriers affect almost all of the surrounding habitat.

5.2.3 Results

This indicator is scored through review of IWMP remote assessment results and confirmation from aerial imagery. Briefly, the Yampa River Remote Assessment delineated the floodplain below Elk River and above Lake Catamount using a variety of data sources, and then overlayed various infrastructure layers (roads, levees, railroads, etc.) to calculate the fraction of the floodplain that was isolated by that infrastructure. Refer to Section 6.2.1.1.3 in the Yampa River Remote Assessment Data Synthesis Report for further details on the methodology (Yampa IWMP 2021). Riverscapes 39-45, which were not included in the geographic scope of the Yampa IWMP, were evaluated in 2022 using the same methodology.

In riverscapes 5 and 6, along with a smaller portion of 16, terrestrial habitat fragmentation is notably minimal (Table 5-4, Figure 5-3). These areas benefit from a relative lack of significant anthropogenic disturbances, contributing to an environment with higher habitat connectivity. The confined nature of riverscapes 5 and 16 likely aids in favorable percentages. The overall health of these riverscapes might be attributed to a combination of land use factors and valley conditions.

Table 5-4. Floodplain Fragmentation Percent by Riverscape

Riverscape	Floodplain Fragmentation
5	99%
6	98%
39	64%
40	66%
41	62%
42	58%
43	22%
44	63%
45	68%
14	67%
15	66%
16	81%

* Adapted from the Yampa River Remote Assessment Data Synthesis Report (Yampa IWMP 2021) and appended with 2022 data for missing riverscapes; higher percentages correspond to minimal fragmentation and lower percentages correspond to greater fragmentation of the landscape.

Conversely, riverscapes 14, 15, and the lower end of riverscape 16 exhibit minor to moderate levels of habitat fragmentation. Various anthropogenic features, such as the railroad and surface roads (e.g., US-40), act as impediments that fragment the floodplain; permeable barriers such as agricultural infrastructure (e.g., fencing, gravel roads) are also present. The community of Milner contributes to the disruption of terrestrial habitats through removal of riparian habitat, construction of residences and businesses, and expansion of the road system. Riverscapes 39-45 were not included in the IWMP but underwent the same analysis. All but 43 exhibited similar levels of moderate fragmentation due to high levels of development and the increased presence of commercial, residential, and agricultural infrastructure. Riverscape 43, located in the heart of Steamboat Springs, showed the highest levels of fragmentation, with only 22% of the maximum terrestrial habitat accessible due to heavier population density, road networks, and development. Reduced terrestrial connectivity and a higher density of impediments in Steamboat and its outskirts may pose increased challenges to habitat connectivity, emphasizing the need for further investigation and targeted conservation initiatives to address potential ecological consequences in these more developed river systems (Table 5-4, Figure 5-3). This indicator does not include floodplain connectivity, riparian condition, or longitudinal connectivity; rather, it is solely a measure of riverscape fractionation due to infrastructure and terrestrial impediments. Scores for the terrestrial connectivity indicator are presented in Table 5-5.

Figure 5-4. Floodplain Fragmentation (Representing Terrestrial Connectivity) by Riverscape

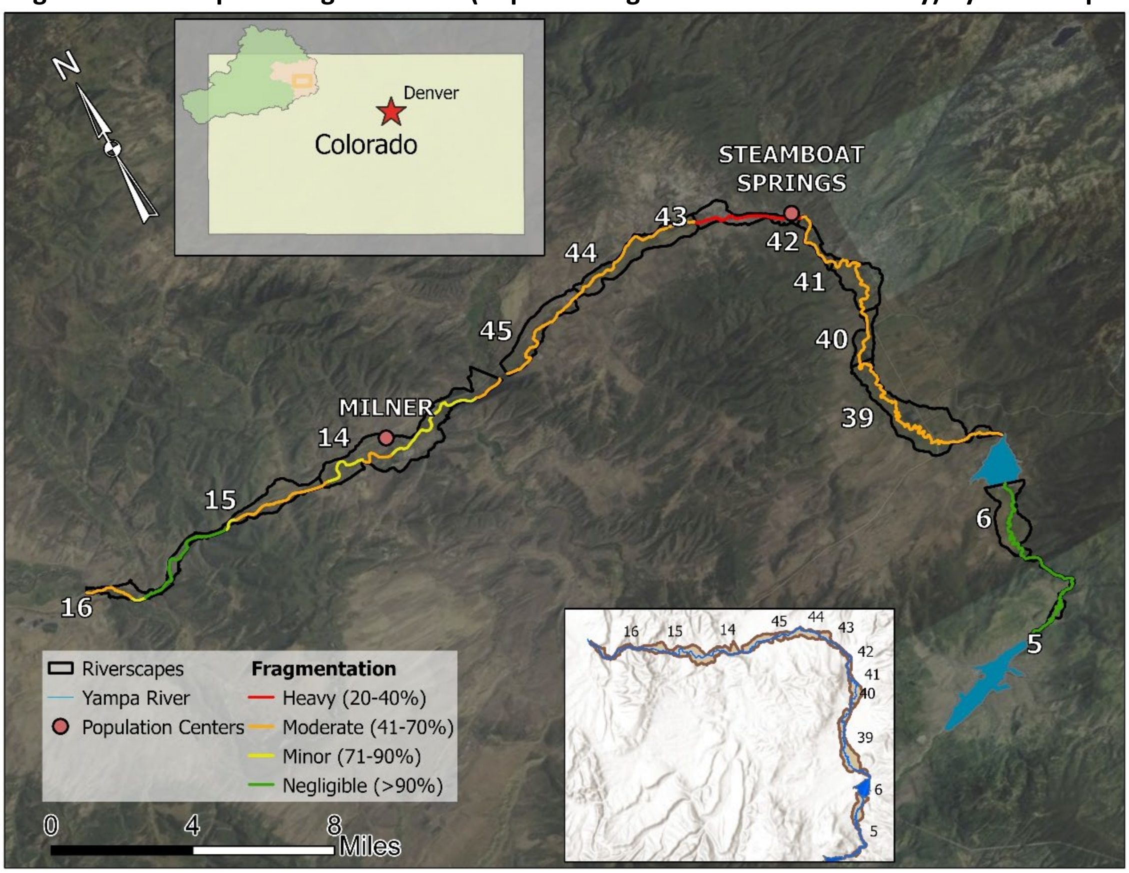


Table 5-5. Terrestrial Connectivity Indicator Scores by Riverscape

Riverscape	Terrestrial Connectivity Score
Riverscape 5	A
Riverscape 6	A
Riverscape 39	C+
Riverscape 40	C+
Riverscape 41	C+
Riverscape 42	C
Riverscape 43	D-
Riverscape 44	C+
Riverscape 45	C+
Riverscape 14	C+
Riverscape 15	C+
Riverscape 16	B

6.0 RIVERSCAPE CONNECTIVITY

Riverscape connectivity is defined as the degree to which water can access and hydrate the surrounding riverscape (channel and floodplain). In particular, riverscape connectivity reflects the ability of the valley bottom to be actively and routinely engaged by fluvial processes. Connectivity varies naturally based on geology, topography, and hydrology. It also reflects impediments due to hydromodifications, channel modifications (e.g., enlargement, entrenchment, channelization/ stabilization), and/or anthropogenic land uses within the floodplain (e.g., levees, drainage ditches, development, fill), which limit hydrogeomorphic processes, dynamism of channel/floodplain interaction, and biological interactions between the channel and its floodplain. The Yampa River Scorecard evaluates riverscape connectivity using a single indicator referred to as **riverscape connectivity**.

6.1 RIVERSCAPE CONNECTIVITY

Riverscape connectivity for the Scorecard project is defined as the ratio of the active floodplain to the maximum possible floodplain extent, as was done for the Yampa IWMP remote assessment. The Yampa IWMP remotely evaluated a Floodplain Connectivity indicator across the entire basin, described as the ratio of the accessible extent of the active floodplain to the maximum potential accessible floodplain (Yampa IWMP 2021). The floodplain connectivity ratio is a proxy measure of the extent and frequency with which flows interact with the channel and adjacent floodplain. This interaction is critical for creating and maintaining a healthy stream corridor by helping establish and maintain riparian vegetation throughout the floodplain, which in turn extends inundation residence times by attenuating and slowing flows through the system.

For the Yampa IWMP remote assessment, floodplain connectivity was assessed across the entire basin, and reassessed using higher resolution data in 6 priority riverscapes, to characterize the capacity of water to inundate and activate the adjacent riparian corridor. The higher resolution data used for a portion of the Middle Yampa and Elk River segments allowed for better identifying and mapping fluvial features and more accurately delineating floodplain extents, and those analyses yielded generation of multipliers that better approximate floodplain connectivity for riverscapes with moderate resolution data. It is important to note that a critical component of accurate floodplain and geomorphic delineations is field verification. While the remote assessment provides a good foundation, the Scorecard effort provides ground-truthing, field verification, and refinement of those results to the extent possible using all available information (described more in Section 6.1.5).

The active floodplain is defined as the extent to which flows can access the land adjacent to the river over <u>frequent to moderate</u> recurrence intervals. The active floodplain delineates the areas where inundation duration and frequency can maintain riparian vegetation and active fluvial processes. To determine the area occupied by active floodplain via remote sensing, two lines of evidence were used: (1) floodplain fragmentation by development and transportation infrastructure, which have disconnected low-lying areas from the active floodplain, and (2) topographic datasets to identify low-lying areas that have the potential to be inundated at frequent to moderate recurrence intervals. Integration of the floodplain fragmentation and the potentially active floodplain layers were used to delineate the active floodplain. The active floodplain is defined as land that is within the potentially active floodplain that has not been disconnected by development or transportation networks. Figure 6-1 shows some of the steps taken to determine the floodplain connectivity ratios for the Yampa IWMP remote assessment from an example riverscape in the Middle Yampa segment (Yampa IWMP 2021).

Figure 6-1. Yampa IWMP Remote Assessment Floodplain Connectivity Metrics Example

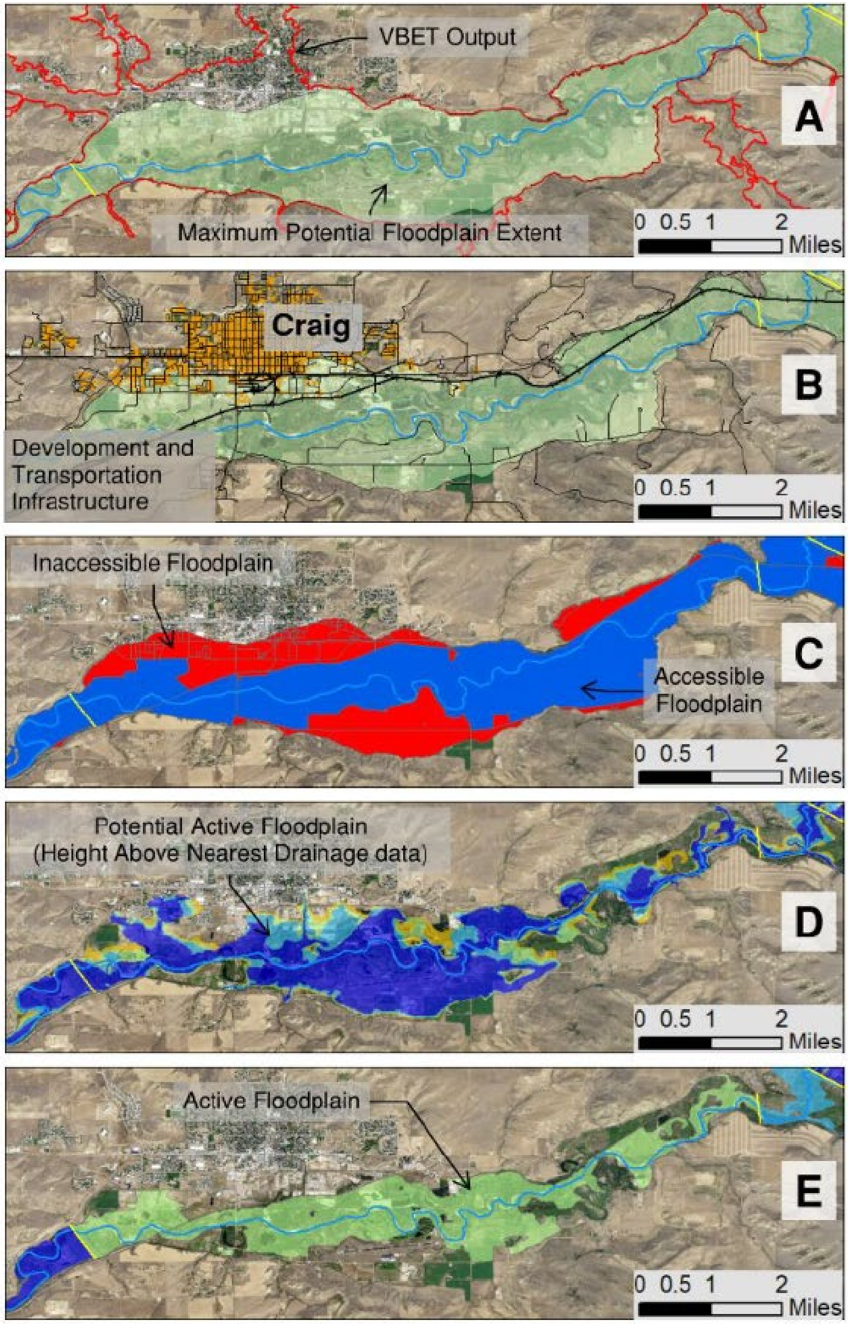


Figure 6-1. Example floodplain connectivity metrics for Riverscape 23 (see Figure 2-4 for context). A) VBET outputs and manually modified valley bottom representing the maximum potential floodplain extent. B) Development and transportation infrastructure overlain on valley bottom polygon. C) Floodplain fragmentation by development and transportation network. D) Potential active floodplain based on Height Above Nearest Drainage. E) Active floodplain.

6.1.1 Data Sources and Evaluation Methods

The Scorecard uses the results of the Yampa IWMP remote assessment floodplain connectivity evaluation to score the riverscape extent indicator, and duplicates this methodology for riverscapes not covered in the Yampa IWMP geographic scope. However, the remote assessments did not include a field verification component. For the Scorecard, the floodplain connectivity ratios for the 12 riverscapes in the Steamboat segment were ground-truthed to the extent possible, particularly in unconfined reaches where remote assessment may have overestimated the maximum potential floodplain extent, through site visits in areas with landowner access permissions. Select sites were visited for field verification by a fluvial geomorphologist and watershed scientist team in October 2023 following review of aerial photography collected during high water in 2011 and 2023 which showed locations of potential inundation outside of the mapped active floodplain. Where discrepancies were identified, the Scorecard alters the IWMP evaluation as necessary based on the field verification exercise and uses an updated score for evaluation per the scoring criteria described in Section 6.1.3.

6.1.2 Scoring Criteria

The scoring criteria outlined in Table 6-1 based on Yampa IWMP remote assessment floodplain connectivity ratios are used rate the riverscape connectivity indicator.

Table 6-1. Riverscape Connectivity Scoring Criteria

Grade	Description
A	Natural pattern of floodplain activation over frequent to moderate recurrence intervals, with a floodplain connectivity ratio of > 90%.
B	Majority of riverscape extent is available for activation over frequent to moderate recurrence intervals, with a floodplain connectivity ratio of 75-90%.
C	Moderate amount of riverscape extent is available for activation over frequent to moderate recurrence intervals, with a floodplain connectivity ratio of 50-74%.
D	Small amount of riverscape extent is available for activation over frequent to moderate recurrence intervals, with a floodplain connectivity ratio of 25-49%.
F	Riverscape activation over frequent to moderate recurrence intervals is extremely limited, with a floodplain connectivity ratio of < 25%.

6.1.3 Results

This indicator is scored using a combination of review of IWMP remote assessment results and data collected during site visits with Scorecard partners. Adjustments to active floodplain polygons generated by the IWMP were made using ground truthing and aerial photograph inspection for riverscapes 5, 6, 39, and 41. Additionally, in place of the IWMP active floodplain delineation, fluvial hazard zone mapping of the active stream corridor (using high-resolution data) was used to replace the IWMP active floodplain delineation (using moderate-resolution data) for riverscapes 14, 15, and 16 (Jagt et al. 2022). Maximum floodplain extents are the same as those delineated in the IWMP report. Additionally, the floodplain connectivity multipliers determined by the IWMP assessment by comparison of floodplain mapping results in areas with high resolution elevation (1-m) data to those in areas with moderate resolution elevation (10-m) data were used here as well.

The highest floodplain connectivity score was found in riverscape 14, where 91% of the floodplain is readily accessible by relatively frequent flows (Table 6-2 and Figure 6-2). The high score for this riverscape was surprising due to terrestrial habitat being moderately fragmented throughout and the presence of the town of Milner, especially because this is one of two true unconfined reaches in the focal segment. This high score is perhaps partially a function of the confluence with Trout Creek, which at high stage appears to access much of the southern portion of the floodplain through the riverscape (Figure 6-2).

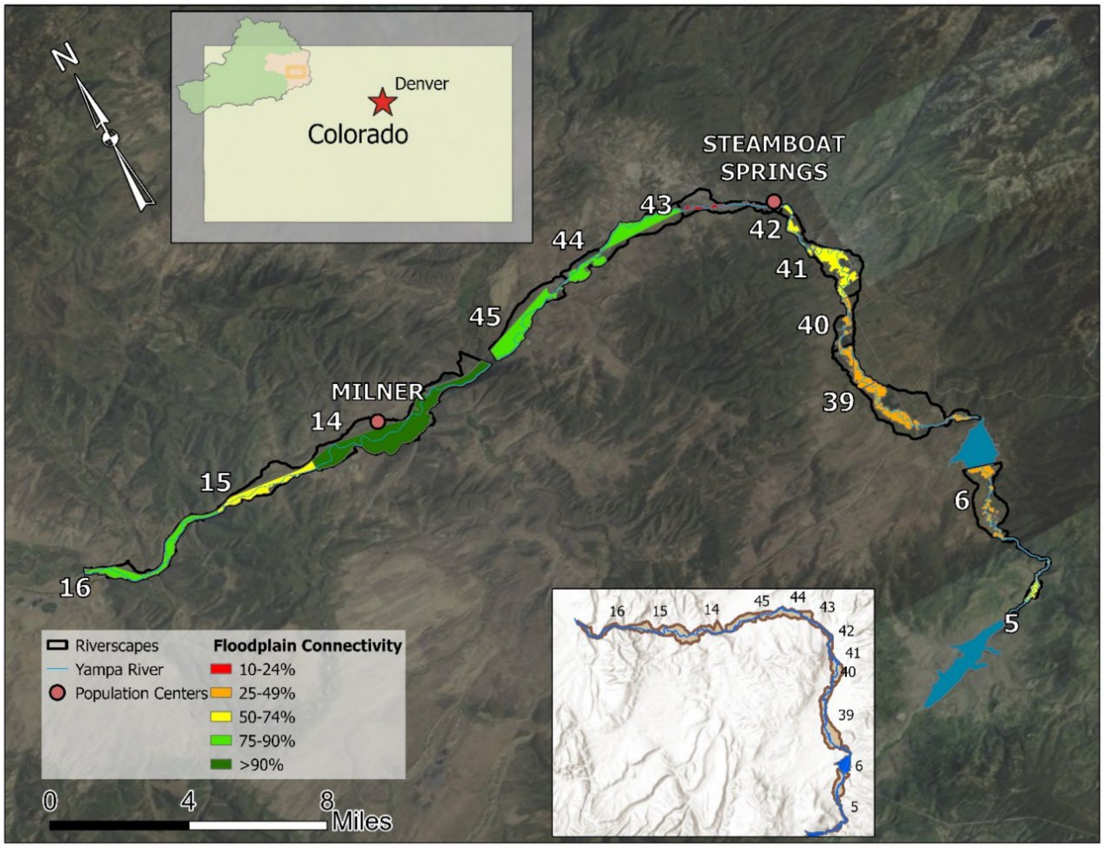
Table 6-2. Confinement and Floodplain Connectivity Percentages by Riverscape

River-scape	Confinement	Max. Potential Floodplain (mi^2)	Active Floodplain IWMP (mi^2)	Active Floodplain YRSP (mi^2)	Floodplain Connectivity (%)	Multi-plier	Adj. Floodplain Connectivity (%)
5	Confined	0.26	0.13	0.15	0.57	1.0	0.57
6	P. Confined	1.30	0.23	0.33	0.25	1.3	0.33
39	Unconfined	2.34	-	0.82	0.35	1.3	0.46
40	Unconfined	0.50	-	0.16	0.32	1.3	0.42
41	Unconfined	0.98	-	0.51	0.52	1.3	0.67
42	P. Confined	0.33	-	0.16	0.49	1.3	0.64
43	P. Confined	0.74	-	0.13	0.18	1.3	0.23
44	P. Confined	1.38	-	0.84	0.61	1.3	0.80
45	P. Confined	1.20	-	0.75	0.62	1.3	0.81
14	Unconfined	2.89	1.40	2.02	0.70	1.3	0.91
15	P. Confined	0.83	0.32	0.46	0.55	1.3	0.71
16	Confined	0.76	0.53	0.64	0.84	1.0	0.84

The next highest scores are for riverscapes 44, 45, and 16, which are greater than 80% connected (Table 6-2 and Figure 6-2). The scores for riverscapes 44 and 45 are also surprising given the proximity to the City of Steamboat Springs, as well as moderate habitat fragmentation within this stretch, but these riverscapes exhibit a rapid change in land use to agriculture outside the City limits. The higher score in riverscape 16 likely arises from the natural confinement of the river in this stretch; opportunities for development or other human actions that render portions of the floodplain inaccessible are typically limited in a confined valley.

Riverscapes 5, 41, 15, and 42 had connectivity percentages ranging from 57-71% (Table 6-2 and Figure 6-2). Riverscape 5 is naturally confined, but also has further confinement due to road infrastructure, bank stabilization features, and agricultural development. Riverscapes 15 and 42 are similarly impacted, but with the addition of highway and railway embankments and higher levels of development. Agriculture, roadways, railways, and development also impact riverscape 41, but the magnitude of impact is lower given the larger floodplain area.

Figure 6-2. Riverscape Connectivity Scores for the Yampa Steamboat Segment



Connectivity percentages for riverscapes 6, 39, and 40 ranged from 33-49% (Table 6-2 and Figure 6-2). These low percentages are due to the high degree of development (transportation, agriculture, etc.) in these areas. US Route 40 and the Union Pacific railroad, for example, cut large portions of the river off from its historically accessible floodplain in all three riverscapes. Further development, such as bank stabilization projects, floodplain manipulation, and levee construction, additionally isolates the river from the floodplain in these riverscapes.

Riverscape 43 earns the lowest riverscape connectivity score, where only 23% of the maximum potential floodplain is accessible (Table 6-2 and Figure 6-2). This riverscape encompasses the City of Steamboat Springs and also had the lowest terrestrial connectivity score, so this finding is expected due to the high levels of development, bank stabilization, and flood control structures in place. Scores for the riverscape connectivity indicator are presented in Table 6-3.

Table 6-3. Riverscape Connectivity Indicator Scores by Riverscape

Riverscape	Riverscape Connectivity Score
Riverscape 5	C-
Riverscape 6	D-
Riverscape 39	D
Riverscape 40	D
Riverscape 41	C
Riverscape 42	C
Riverscape 43	F
Riverscape 44	B-
Riverscape 45	B
Riverscape 14	A
Riverscape 15	C+
Riverscape 16	B

7.0 RIPARIAN CONDITION

Riparian areas, or lands that occur along and are influenced by watercourses, are a critical part of a healthy and resilient stream ecosystem, providing physical roughness that slows water velocities and mitigates the impacts of flood flows; bank stability through root system cohesiveness; habitat for a diversity of riparian plants, animals, and microbes; water quality improvement; shade for the stream corridor to maintain a healthy thermal regime; large wood to stream channels, which creates beneficial habitat complexity; organic matter to the water column; and off-channel habitats like backwaters, wetlands, and side channels that act as refugia for fish and other aquatic species. Well-established and connected riparian areas also link stream corridor and upland ecological processes. Riparian condition is defined as the degree to which riparian areas support river health and critical functions. The Yampa River Scorecard evaluates two indicators within the riparian condition category: **vegetation structure and complexity** and **invasive species**. The final riparian condition score is calculated as 90% vegetation structure and complexity indicator score and 10% invasive species indicator score.

7.1 VEGETATION STRUCTURE AND COMPLEXITY INDICATOR

The vegetation structure and complexity indicator describes riparian vegetation and its ability to support characteristic riparian functions. Healthy riparian zones are characterized by a high level of vertical and horizontal complexity, including a mosaic of habitat types and multiple vegetation layers. Included in these considerations are structure, height, cover, species diversity, complexity, age, and patchiness/interspersion of riparian vegetation. The character and complexity of riparian vegetation are primarily driven by above ground saturation and the associated disturbance caused by seasonal flooding, alluvial groundwater, and erosional and depositional changes that create bars and distribute overbank fine sediment. Complex riparian corridors in turn influence a spectrum of physical functions in the river ecosystem while providing critical wildlife habitat.

Riparian condition is evaluated within a limited portion of the maximum potential floodplain as defined in the riverscape connectivity category. In particular, it is evaluated out to a maximum of 100 meters from each channel bank. The maximum potential floodplain – and therefore potential extent of riparian vegetation – is typically considerably wider than 200 meters on the Yampa River, particularly in several of the riverscapes within the Steamboat segment. The limited scope of the riparian condition category represents a compromise between data acquisition and available resources. The condition and extent of riparian vegetation is evaluated near the channel where it exerts the greatest control on river health, but the condition of riparian vegetation in the wider riverscape is not assessed. Future assessments will seek to expand the breadth of riparian vegetation mapping within the maximum potential floodplain in order to chart riverscape-scale changes in land cover and land use.

7.1.1 Data Sources and Evaluation Methods

Vegetation structure and complexity are evaluated using the remote polygon methodology applied in the City of Steamboat Springs SMP's river health assessment (City of Steamboat Springs 2018), with the lateral extent of the riparian zone defined as the edge of the natural floodplain or 100 meters from each river bank (200 meters total terrestrial width), whichever is narrower. This approach entails the following steps:

(1) Create and classify polygons within the riparian zone by land cover (e.g., cottonwood forest, sub-canopy forest, scrub-shrub, herbaceous, vegetated/non-vegetated bar, wetland, developed, bare ground, open water) and land use (e.g., ranch lands, light agriculture, residential development, commercial-industrial, park lands, naturalized open space, disturbed open space, transportation corridor);
(2) conduct initial desktop grading on polygons created in step 1;
(3) field verify and refine initial polygons, particularly for polygons with natural-looking riparian vegetation;
(4) perform a calibrated grading based on information from field verification step 3;
(5) grade each cover type polygon based on Table 7-1, below; and
(6) calculate an area-weighted average of all polygon scores within each riverscape to produce a single vegetation structure and complexity indicator score for each riverscape.

More details regarding the methodology for this approach are provided in Appendix B.

7.1.2 Scoring Criteria

The scoring criteria outlined in Table 7-1 based on the ability of the riparian corridor to support river health functional attributes are used to rate the vegetation structure and complexity indicator.

Table 7-1. Vegetation Structure and Complexity Indicator Scoring Criteria

Grade	Description
A	Native riparian conditions exist that appear natural and appropriate for the Yampa River. Woody vegetation is present and commonly dominant, but patches and ribbons of meadow are typical. Vegetation is characteristically patchy, with strong interspersion of patches and overall good vertical structure driven by connection to the river. No evident effects of stressors – many stressors ameliorated by frequent flooding. Examples include cottonwood forest on well-connected surfaces such as vegetated point bars; young, characteristically willow-dominated, vegetation on recently formed surfaces; low, in-channel benches protected from human manipulation, typically scrub-shrub. Full support of river health.
B	Riparian habitat resembles native conditions but with detectable changes or mild, evident stressors. Vegetation appears self-sustaining and requiring little or no maintenance to preserve characteristic structural diversity. Habitat maintains a high degree of patchiness and interspersion, with little homogenization or loss of vertical structure. Small habitat patches can be relatively homogenous but contribute to the local mosaic of habitats. Common examples include river-connected cottonwood canopy and subcanopy forest with impacts such as grazing and primitive roadways. Minor reduction in the support of river health attributes.
C	Vegetated but with substantial departure from native conditions. Most commonly, alterations result in a loss of structural complexity, and/or homogenization of vertical structure, patchiness, and/or interspersion. Examples include cleared pastures that contain scattered trees and shrubs; fallow floodplain hayfields and cottonwood forests with substantial understory alteration; and palustrine

	emergent wetlands associated with ditches and sloughs. Riparian condition contributes to the degradation of one or more river health processes.
D	Dramatic loss of structural complexity, and/or homogenization of vertical structure, patchiness, and interspersion. Habitat commonly isolated from the river. Bare ground or impervious surfaces commonly makes up a significant portion of land cover. Vegetation tends to be very disturbed or actively cultivated. Examples include actively cultivated hay fields, old gravel mines, primitive roadways, and golf courses. Riparian land use contributes to river dysfunction.
F	Riparian area is developed or wholly converted with predominantly bare ground, impervious surfaces, or otherwise lacking in vegetation as a result of land use and management actions. Riparian habitat function is essentially extinguished, and land use contributes substantially to river dysfunction.

7.1.3 Results

The remote polygon desktop exercise with field verification was completed in summer/fall 2023. Refer to Appendix B for a technical memorandum describing methods and results in more detail. A summary of the results is provided below.

The riparian zone for the Steamboat segment was divided into 1,104 polygons based first on land cover and then land use. Of the 10 cover types designated, herbaceous cover was by far the most common, accounting for more than 1,000 acres. Herbaceous areas were mostly hayfield and pasture lands. Scrub-shrub, developed lands, and subcanopy forest were the next three most common cover types, which illustrates the rural nature of the landscape but also highlights the significant amount of developed land associated with the City of Steamboat Springs. The cover types with the best mean condition were those in closest association with the river, including vegetated bars, scrub-shrub habitats, and cottonwood forests. These areas are continually disturbed by natural processes and recover rapidly, so in most cases signs of human disturbance are quickly erased. Subcanopy forests and flowing open water are next in terms of condition, and excellent examples of both land cover types still exist on features shielded from intensive human use. As expected, developed polygons were assigned the lowest scores.

Following the pattern in land cover, ranchland and agricultural land uses are the most prevalent land uses in the Steamboat segment. It should be noted that there is little distinction between these two land uses, and they often overlap spatially or temporally. The agricultural land use implies that the polygon is under active cultivation, usually for hay. It is acknowledged that fields are continually taken in and out of production, and it is not always possible to determine whether and area is being actively hayed, used as pasture, or simply has abundant herbaceous cover. Naturalized open space areas, particularly in the vicinity of the City of Steamboat Springs, also account for a large portion of the land use in the Steamboat segment. With ranchlands encompassing several different land cover types, scores have a wide range (between A and F), but an important finding is that ranchlands hold many of the Yampa Valley's finest examples of riparian habitat and, overall, the average score for these habitats is a B.

Riparian condition scores based on land cover and land use were weighted by area to compute an overall riparian condition score for each of the twelve riverscapes in the Steamboat segment. Examples of the fine-scale riparian mapping that was completed for this assessment are provided in Appendix B, and final weighted averages by riverscape are shown in Table 7-2. The riverscapes of a more rural nature (i.e., those on the upstream and downstream ends of the Steamboat segment and farther away from the developed lands within the City) scored in the B-/C+ range, while the riverscapes in closer proximity to City-related development and infrastructure scored lower, in the C/D range. Not surprisingly, riverscape 43 through the City of Steamboat Springs earned the lowest score (D).

Table 7-2. Vegetation Structure and Complexity Scores by Riverscape

Riverscape	Riparian Condition Score
Riverscape 5	C+
Riverscape 6	C+
Riverscape 39	C
Riverscape 40	C+
Riverscape 41	C+
Riverscape 42	C-
Riverscape 43	D
Riverscape 44	C+
Riverscape 45	B-
Riverscape 14	B-
Riverscape 15	B-
Riverscape 16	B-

7.2 INVASIVE PLANT SPECIES INDICATOR

The invasive species indicator provides a measure of the presence and relative proportion of several invasive plant species that are common in the Yampa Valley, including leafy spurge, Russian olive, and tamarisk.

Leafy spurge is a Colorado List B noxious weed species. It is a deep-rooted perennial that spreads explosively by seed and has extensive, creeping roots. Leafy spurge is adapted to a wide range of habitats and is very competitive with other plant species, crowding out nearly all other vegetation when it becomes established in rangeland, pasture, and riparian sites. Its white, milky sap is extremely toxic to cattle and horses, and damaging to sensitive human skin and eyes. The Yampa River Leafy Spurge Project (YRLSP) has been working to map and manage the infestation of leafy spurge in riparian areas in the valley since 2015.

Russian olive, another Colorado List B species, is a perennial tree or shrub that reproduces by seed or root suckers. Once thought to be a beneficial windbreak tree, Russian olive is detrimental to riparian zones because it outcompetes native plants, interferes with natural plant succession and nutrient cycling, and disadvantages several native animal species relative to native vegetation.

Tamarisk, or saltcedar, is also a Colorado List B noxious weed. It was introduced for ornamental purposes and streambank stabilization but is now widespread in the US and crowds out native stands of riparian and wetland vegetation. Tamarisk increases the salinity of surface soils, rendering them inhospitable to native plant species.

7.2.1 Data Sources and Evaluation Methods

The Yampa River Leafy Spurge Project (YRLSP) conducted field mapping of leafy spurge along the Yampa River from Hayden, CO, to Cross Mountain in 2019-2021. This field data was used by a University of Wyoming graduate student to build a remote sensing model of current leafy spurge infestation in the Yampa Valley. Based on identified attributes of highly infested areas, a predictive model was developed to identify areas at risk for future invasion, as well. A presentation describing this project and explaining modeling results is available at (https://www.yampariverleafyspurgeproject.com/chloemattilio) on the YRLSP website. The remote sensing project yielded > 83% confidence that leafy spurge is correctly detected by remote sensing methods, so the final remote sensing maps and risk model are used as the primary data source for scoring the invasive species indicator.

Data to score this indicator are also collected by floating or walking most of the Steamboat segment and noting instances of Russian olive and tamarisk. These observations are documented via photographs and notes, and observations of Russian olive and tamarisk are scored based on presence/absence of either species. In particular, a score of 0 is assigned if no Russian olive or tamarisk is observed on either bank within a riverscape, and 1 point is assigned if at least one individual is observed on either the left or right bank for either species. For example, if Russian olive is observed on one of the two banks in a riverscape, but tamarisk is not observed, the score is 1. If both Russian olive and tamarisk are observed on one bank, the score is 2. If both species are observed on both banks, the score is 4. Scores for these invasives range from 0 to 4 points.

Because the data collection and modeling methods were more rigorous for the leafy spurge data, these results are weighted more heavily than the other invasives to derive a final invasive species indicator score.

7.2.2 Scoring Criteria

The scoring criteria outlined in Table 7-3 based on YRLSP leafy spurge mapping and qualitative field observations of Russian olive and tamarisk are used to rate the invasive species indicator. Scoring is mainly driven by leafy spurge data.

Table 7-3. Invasive Species Indicator Scoring Criteria

Grade	Description
A	No or only trace amounts (<1%) of leafy spurge present in the riparian area. No observations of Russian olive and/or tamarisk noted (invasives score of 0).

B	Low coverage (1-5%) of leafy spurge present in the riparian area. Infrequent observations of Russian olive and/or tamarisk noted (invasives score of 0-1).
C	Moderate coverage (6-25%) of leafy spurge present in the riparian area. Moderate number of observations of Russian olive and/or tamarisk noted (invasives score of 0-3).
D	High coverage (26-50%) of leafy spurge present in the riparian area. Frequent observations of Russian olive and/or tamarisk noted (invasives score of 2-4).
F	Very high coverage (51-100%) of leafy spurge present in the riparian area. Consistent to constant observations of Russian olive and/or tamarisk noted (invasives score of 4).

7.2.3 Results

Field observations did not reveal the presence of invasive species, including tamarisk, Russian olive, or leafy spurge, throughout the entirety of the accessible focal segment. This included on-foot and boating observations. However, a noteworthy concern arises from the analysis of remote sensing data provided by the Yampa River Leafy Spurge Project (YRLSP), which underscores the heightened risk of future invasions by leafy spurge in these riverscapes (Figure 7-1).

These remote sensing findings indicate that, despite the absence of invasive leafy spurge upstream of Hayden, confirmed through data and personal communications (P. Williams, personal communication 2022), the possibility of invasion is real. The YRLSP model suggests that a substantial portion of floodplain areas in the Steamboat riverscapes may be susceptible to colonization by non-native leafy spurge, with the highest risk located around and within the City of Steamboat Springs in the vicinity of riverscapes 42 and 43 (Table 7-4). Further communication with the YRLSP team indicates that there are minor populations of leafy spurge beginning to establish in the uplands above Stagecoach Reservoir, but the valley bottom has not been impacted yet. Biological controls, in the form of co-adapted flea beetles in the genus Aphthona, as well as a stem-boring beetle (*Oberea erythrocephala*), have been released in the Yampa River valley to manage the spread of this invasive weed. The closest of these control species releases to the Steamboat segment was just upstream of Hayden, 5.2 miles below the downstream extent of riverscape 16 (YRLSP 2023). While these findings currently have no effect on scoring these segments (Table 7-5) due to the lack of current invasion in the lowlands, the risk model underscores the imperative for proactive management and ongoing monitoring to mitigate the imminent threat of invasions in these ecologically sensitive regions.

Figure 7-1. Remotely-Sensed Leafy Spurge Risk Across the Yampa Steamboat Segment

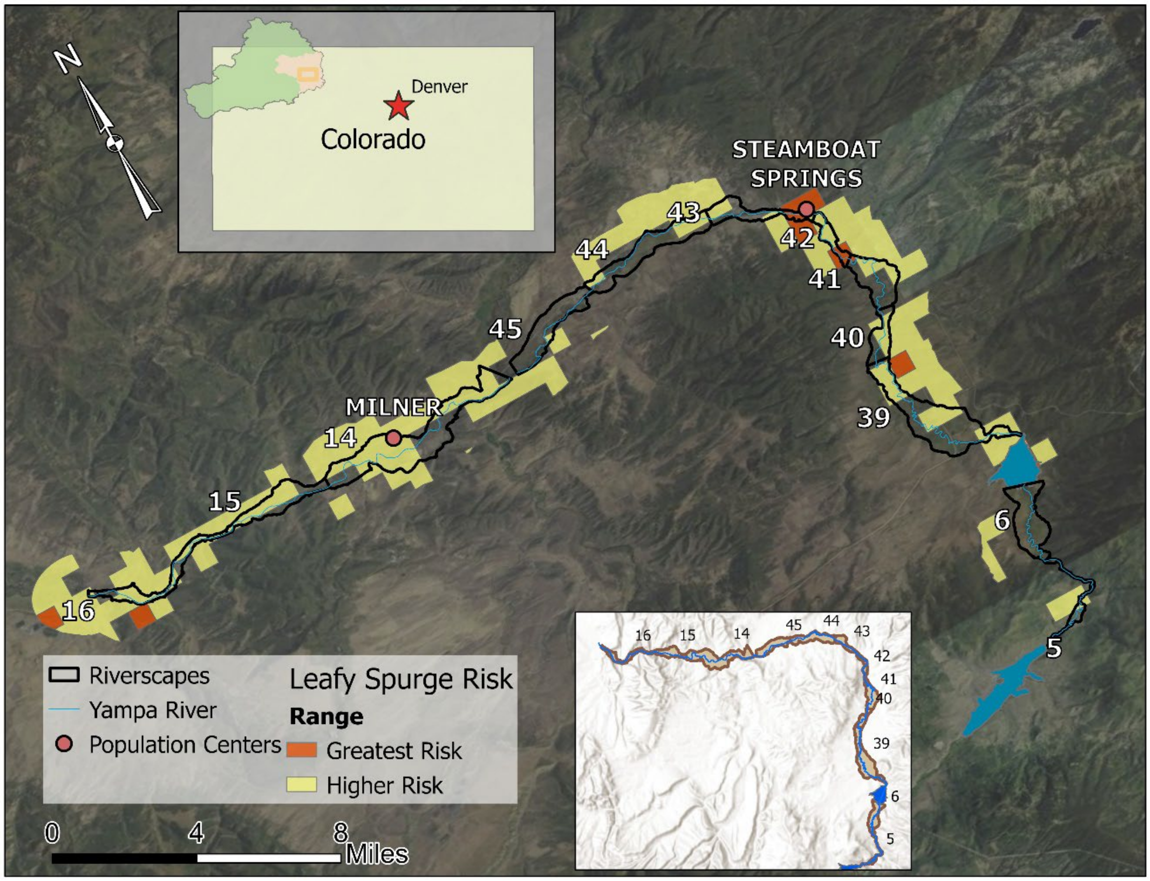


Table 7-4. Leafy Spurge Risk by Riverscape in the Yampa Steamboat Segment

Riverscape	Higher Risk Percent by Area (%)	Greatest Risk Percent by Area (%)
Riverscape 5	17.0	0
Riverscape 6	0	0
Riverscape 39	43.1	0.07
Riverscape 40	53.4	0
Riverscape 41	33.7	2.2
Riverscape 42	70.7	28.7
Riverscape 43	36.3	16.3
Riverscape 44	28.5	0
Riverscape 45	3.5	0
Riverscape 14	67.3	0
Riverscape 15	65.2	0
Riverscape 16	79.2	0.02

Table 7-5. Invasive Species Indicator Scores by Riverscape

Riverscape	Tamarisk/Russian Olive Score	Leafy Spurge Score	Invasive Species Score
Riverscape 5	A	A	A
Riverscape 6	A	A	A
Riverscape 39	A	A	A
Riverscape 40	A	A	A
Riverscape 41	A	A	A
Riverscape 42	A	A	A
Riverscape 43	A	A	A
Riverscape 44	A	A	A
Riverscape 45	A	A	A
Riverscape 14	A	A	A
Riverscape 15	A	A	A
Riverscape 16	A	A	A

8.0 RIVER FORM

River form is defined as the river channel shape and geometry. It is directly influenced by the physical attributes of the watershed (e.g., geology, topography, hydrology), channel hydraulics, sediment transport, and local hillslope and floodplain uses (e.g., adjacent roadways, grazing). Biological drivers (e.g., riparian vegetation, large woody material, beaver activity, aquatic vegetation) influence river form as well, by altering hydraulics and erosional patterns. The Yampa River Scorecard evaluates river form holistically, using a single indicator referred to as **channel morphology**.

8.1 CHANNEL MORPHOLOGY INDICATOR

The channel morphology indicator is scored holistically and qualitatively considering planform shape (aerial shape), dimension (cross-sectional shape/size), and profile (slope). In some cases, quantitative measurements are used to inform qualitative scoring.

8.1.1 Data Sources and Evaluation Methods

A combination of remote sensing, quantitative measurements, and field observations are used to score the channel morphology indicator. Planform shape can be evaluated through remote measurement of valley confinement and parameters such as sinuosity. Comparison of historical and current aerial imagery can also be helpful. A stressor-based approach is also employed to evaluate channel morphology, with a component of the fieldwork that includes taking note of low-head dams, diversions, and bank- and in-channel treatments that may impact grade (Appendix A).

The Scorecard effort acknowledges that channel morphology assessments that employ traditional metrics have been conducted on river systems that had been long impacted by controls that reduce complexity, leading to the narrow view of rivers as channels having easily-measured forms. For the Scorecard, these metrics are used in the context of a progression from the past to the present, as well as evaluating where they fall on a continuum of stability. In this manner, channel form that falls outside of the natural continuum to be expected of a healthy river can be evaluated as indicative of a river that has some issues. The Scorecard public interface explains these differences.

This indicator is scored using best professional judgement supported by the observations and measurements described above. Expert opinion is based on data collected and observed in the field, aerial imagery, and GIS spatial data to generate a single score for the channel morphology indicator.

8.1.2 Scoring Criteria

The descriptive, qualitative scoring criteria outlined in Table 8-1 are used to rate the channel morphology indicator. The criteria relate primarily to the presence of stressors and level of maintenance required to maintain functional river processes.

Table 8-1. Channel Morphology Indicator Scoring Criteria

Grade	Description
A	Planform, sinuosity, meander-wavelength to bankfull-width ratios, and variations are appropriate for a well-functioning river of this flow/sediment regime and landscape setting. There are no significant constraints to river planform or significant artificial changes in slope (e.g., dams, channelization, grade control structures). Channel geometry is within a range that is natural and appropriate for a well-functioning river in its process domain. The channel geometry is self-sustaining under natural channel processes and requires no maintenance.
B	Planform, sinuosity, meander-wavelength to bankfull-width ratios, and variations are within a range that is natural and suitable for a river of this flow/sediment regime and landscape position. Stressors are detectable but minimal management is needed to maintain functionality. Minor localized impacts exist that minimally affect channel entrenchment, capacity, or width-depth ratios.
C	Stressors on the river planform and/or sinuosity and/or wavelength-width ratios impact localized portions of the channel. Examples include reaches with short lengths of bank armoring (decreased sinuosity) or reaches that have been slightly straightened (decreased wavelength-to-width ratios). Stressors are common along the reach and management is likely required to maintain functionality. Moderate impacts exist that significantly affect channel entrenchment, capacity, or ratios.
D	Widespread stressors impact the river planform, such as floodplain encroachment, hardened banks, or planform straightening. Major bank armoring and/or significant changes to sinuosity or meander wavelength are present, such as reaches with large (>3 feet) grade control structures and moderate planform changes. Active management and maintenance are required to maintain functionality. Widespread impacts exist that severely affect channel entrenchment, capacity, or width-depth ratios.
F	Widespread stressors cause severe impacts or changes to the planform and slope. Examples include anastomosed or meandering streams that were straightened or channelized, rivers with severe floodplain encroachment or armoring of banks, and streams with very large (>6 ft) grade control structures. Stressors are extensive throughout the reach and the level of impairment results in an inability to maintain characteristic function. Profound impacts exist with near-complete alteration of channel entrenchment, capacity, or width-depth ratios. Intensive or consistent active management and maintenance are required. Severe changes to slope are evident.

8.1.3 Results

The channel morphology indicator is evaluated through remote sensing analysis using aerial imagery and GIS spatial data, as well as qualitative field observations. Various morphological calculations were made to evaluate planform in the context of what would be expected for a river in the process domain of the Steamboat segment, including sinuosity and meander wavelength to channel width ratios (l/w). Fieldwork completed for the Scorecard project included stressor-based observations that are relevant for channel morphology. Every riverscape was visited either on foot or through floating the mainstem, except for approximately 40% of riverscapes 6 and 39.

The highest relative scores for the channel morphology indicator in the Steamboat segment are in riverscapes 6 and 14. In riverscape 14, the riparian ecosystem retains much of its natural character and the river appears well connected to the available floodplain, despite moderate terrestrial habitat fragmentation. Inhibitions to natural channel processes, including armoring and limitations by road and railroad infrastructure, are present in this reach, but these inhibitions are minimal compared to adjacent reaches. Additional complexity features such as prolific evidence of lateral mobility, wood accumulation, and beaver activity are indicative of a moderately well-functioning river system (see Section 9.1; Appendix A, Photos A-1 through A-4, Photos A-25 through A-27, and Photos A-17 through A-20, respectively). Sinuosity values and l/w ratios (Table 8-2) are low for a mixed-load river (Schumm 1985, Nicoll and Hickin 2010), though this is consistent with the presence of bank stabilization features and other stressors. Riverscape 6 has more nuance due to the presence of heavier manipulation of the channel planform as a result of restoration actions. Riverscape 6 has limited riparian habitat and floodplain connectivity, despite higher terrestrial connectivity scores. The limitations imposed on the river here stem from agricultural management of lateral movement to protect hay fields and other agricultural infrastructure. Extensive restoration efforts have been implemented throughout the riverscape to create trout habitat and stabilize the river over time, including placement of root wrap, ballast wood and boulders, and management of the channel planform, including meanders (Appendix A, Photos A-37 through A-40). Sinuosity calculations are closer to expected, but still low, and a function of intentional meander placement rather than natural development, while l/w values are within the natural range for a river of this size. Riverscapes 14 and 6 receive B+ and B channel morphology scores, respectively.

Table 8-2. Confinement, Sinuosity, and Meander Wavelength to Bankfull Width Ratio (l/w) by Riverscape

Riverscape	Confinement	Sinuosity	l/w
5	Confined	1.21	13.92
6	Partly Confined	1.38	13.15
39	Unconfined	1.42	13.02
40	Unconfined	1.20	7.91
41	Unconfined	1.63	11.52
42	Partly Confined	1.16	31.80
43	Partly Confined	1.02	48.68
44	Partly Confined	1.23	19.72
45	Partly Confined	1.22	21.13
14	Unconfined	1.26	19.74
15	Partly Confined	1.11	21.21
16	Confined	1.15	27.30

Riverscapes 39, 40, and 41, all unconfined reaches, are closer to the City of Steamboat Springs, which brings additional stressors from increases in road surfaces and development. All three riverscapes have moderate floodplain and terrestrial connectivity scores due to confinement and stabilization measures implemented for housing, roadways, and railroads. Other stressors, such as bank manipulation to protect recreational, industrial, and agricultural lands, are prevalent in these reaches. These stressors include increased frequencies of armoring, including armoring with cars and other debris; diversion structures; and flood control measures in the form of cross-vanes and in-channel rock structures (Appendix A, Photos A-9 through A-14). Sinuosity values are moderately low for unconfined rivers in riverscapes 39 and 41, but very low in riverscape 40 which also has a very low l/w ratio due limited availability of meanders, and increased distances between, because much of the riverscape is occupied by settling ponds. These three riverscapes receive C+ scores for the channel morphology indicator (Table 8-3).

River morphology in riverscapes 44 and 45 is similarly impaired, but with substantially less in-channel manipulation. These riverscapes show greater prevalence of intact riparian areas and presence of large wood, beaver activity, and lateral movement pathways and complexity (see Section 9.1). Both riverscapes 44 and 45 had relatively high riverscape connectivity scores (Table 6-3), but terrestrial connectivity was moderate due to the continued presence of agricultural infrastructure, and road and railway impediments (Table 5-5; Appendix A, Photos A-28 through A-31). Though l/w ratios are within the range of natural variability for freely meandering, unconfined channels, sinuosity is rather low for a reach of this character (Table 8-2). Riverscapes 15 and 16, confined and partially confined reaches, have similar impacts and similar frequencies of healthy indicators of intact natural processes; however, due to confinement the magnitude of both negative and positive impacts are greater. Throughout both reaches, riparian areas, wood, and evidence of lateral mobility, in the form of bars and flow separation, are prevalent (see Section 9.1). Impacts in the form of armoring and structures associated with roads and railways are also prevalent, especially on the north side of the river. Sinuosity and l/w scores, however, are within the range of expected values and floodplain connectivity and terrestrial connectivity are both more favorable. For these reasons, riverscapes 44, 45, 15, and 16 earn a channel morphology score of B- (Table 8-3).

Riverscape 5, at the upstream end of the Steamboat segment, is confined by its valley, and is further confined at the upper end by Stagecoach Dam access roads and at the lower end by other smaller public roads. The upper and lower ends of riverscape 5 contain frequent in-channel placement of cross-vane rock structures and single boulders intended to increase habitat development and protect road infrastructure within the narrow valley. The middle third of riverscape 5 has less frequent anthropogenic manipulation, and overall sinuosity and l/w values are within the expected range of variability. However, evidence of riparian impacts and bank erosion due to agriculture is observed. While lateral movement is indeed indicative of healthy erosional processes, riverscape 5 shows increased levels of instability and frequent minor bank collapse with limited ability to recover (Appendix A, Photos A-41 and A-42). Riverscape 5 receives a score of C (Table 8-3).

Finally, riverscapes 42 and 43 receive the lowest channel morphology scores. Both riverscapes are severely impacted by anthropogenic stressors and have low connectivity scores, as well as low sinuosity and high l/w scores, outside the natural expected range (Nicoll and Hickin 2010, Table 8-2). Frequent occurrences of bank and channel structures placed to stabilize and manipulate flow are present throughout both riverscapes, as well as limited evidence of natural complexity. The river is substantially confined by armoring, concrete walls, and road/rail infrastructure (Appendix A), and has limited lateral or habitat complexity in the form of wood, morphological features, or riparian habitat. Riverscapes 42 and 43 therefore receive D+ scores for the channel morphology indicator (Table 8-3).

Table 8-3. Channel Morphology Scores by Riverscape

Riverscape	Channel Morphology Score
Riverscape 5	C
Riverscape 6	B
Riverscape 39	C+
Riverscape 40	C+
Riverscape 41	C+
Riverscape 42	D+
Riverscape 43	D+
Riverscape 44	B-
Riverscape 45	B-
Riverscape 14	B+
Riverscape 15	B-
Riverscape 16	B-

9.0 STRUCTURAL COMPLEXITY

Structural complexity is defined as the degree of heterogeneity and physical composition of a stream that results from interactions between flow regime, sediment dynamics, and other factors. The more complex and heterogeneous the physical structure of a stream, the more enhanced the habitat for resident aquatic species. Structural complexity considers hydraulic characteristics (water depth and velocity patterns), bed and bank features, and substrate material. In scoring the indicators in this category, a concerted effort is made to integrate quantifiable records and observations from fieldwork conducted by educational partners. Two indicators are included in the structural complexity category: **macrohabitat** and **microhabitat**. The final structural complexity score is calculated as 75% macrohabitat and 25% microhabitat indicator scores.

9.1 MACROHABITAT INDICATOR

The macrohabitat indicator considers physical habitat relevant to fish and larger animals, including distribution and diversity of water depth, velocity, and physical cover, shape of bed and bank features, heterogeneity of habitat, and other large physical structure provided by rock, wood, vegetation, etc. Macrohabitat includes cobble/sand bars, undercut banks, presence/absence of secondary channels/backwaters, and presence, extent, and quality of large wood.

9.1.1 Data Sources and Evaluation Methods

The following features that are important for heterogeneity and complexity within the channel are evaluated in the field, usually from a boat:

- Bedforms including riffles, runs, pools, and glides;
- Split flows (i.e., two narrow channels versus one wide channel);
- Secondary channels (count, GPS, presence of water yes/no);
- Point bars (characteristics: vegetated, cobble, gravel, sand; size);
- Signs of beaver activity (chews, dams, side channel dams, bank dens);
- Presence, size, and quality of large wood;
- Reinforced bank length and type (GPS start and end of reinforced banks on both sides of channel and indicate material (concrete, car bodies, riprap, etc.);
- Undercut bank length; and
- Backwater areas.

Fieldwork to inform this indicator was completed during mid-June and late July 2023, in partnership with CMC and local landowners. Data was collected from a boat, or by foot where necessary, and supplemented with aerial imagery. To the extent possible, these features were enumerated, representative photos are taken, and measurements are quantified and marked with a GPS device (Appendix A). These quantitative measurements feed into the quantitative scoring described in detail in Table 9-1.

9.1.2 Scoring Criteria

The scoring criteria outlined in Table 9-1 based on estimates of diversity of depth/velocity combinations, topographic complexity of beds and banks, and physical structure of the reach are used to rate the macrohabitat indicator.

Table 9-1. Macrohabitat Indicator Scoring Criteria

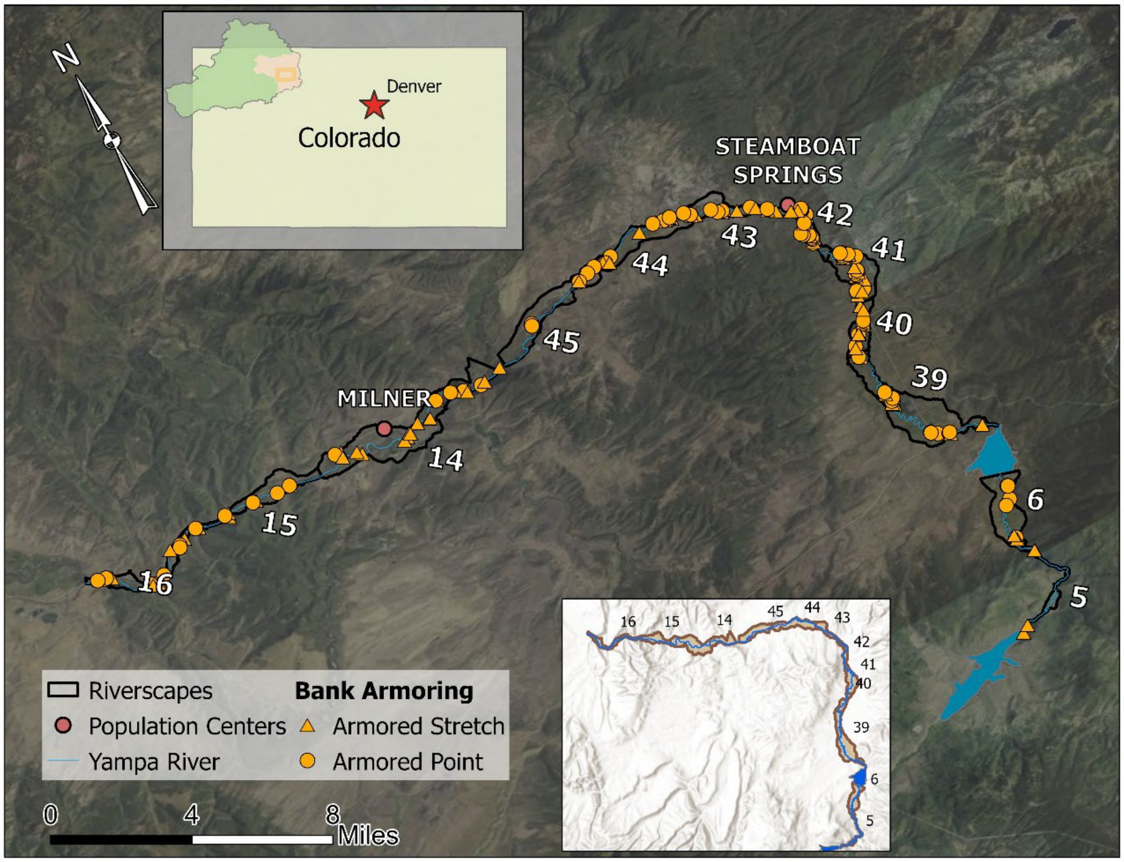
Grade	Description
A	Macro-scale structural heterogeneity is natural and appropriate for a well-functioning river in its process-domain. All velocity-depth combinations and structural components (features formed by wood, rock, vegetation, and debris dams/jams) are present in characteristic distribution.
B	Most typical velocity-depth combinations are present, but distribution of structural components (features formed by wood, rock, vegetation, and debris dams/jams) is slightly skewed due to dispersed stressors or minimal direct impacts. Pools provide adequate cover for fish and other aquatic organisms.
C	Some typical velocity-depth combinations or characteristic structural elements (features formed by wood, rock, vegetation, and debris dams/jams) are absent or limited. Pools provide some cover for fish and other aquatic organisms. Examples include reaches with increased pool/run habitat, lack of off-channel habitat, or skewed riffle-pool ratio. Reaches with artificial structure or hardened/revetted banks also fall into this category.
D	Some typical velocity-depth combinations or characteristic structural elements (features formed by wood, rock, vegetation, and debris dams/jams) are absent, making the reach uncharacteristically homogeneous. Pools may provide minimal cover for fish and other aquatic organisms. Examples include reaches with graded or heavily armored banks, or with features that are frequently limited by inundation or low flow.
F	Homogeneous form with uniform velocity-depth pattern, lack of physical structure, and lack of pools. Examples include reaches with severely homogenized physical characteristics such as unnatural plane-bed morphology.

9.1.3 Results

Macrohabitat was scored holistically by the consideration of the variables outlined in the scoring scheme above, several of which comprise criteria considered for additional indicators herein. Rather than an indicator of redundancy, this instead illustrates the broad, integrative nature of the river landscape in setting the habitat template. Data evaluated here was gathered from field floats and hikes of the riverscapes in consideration and informed by review of current and historical aerial imagery.

Bank armoring (e.g., Figure 9-1; Appendix A, Photos A-5 through A-8) is likely the most consistently detrimental factor with regard to relatively diminished structural heterogeneity (and thus macrohabitat). Bank armoring contributes to reach homogenization and increased resistance to the drivers of river complexity, mainly channel migration and the formation of secondary channels. In-bank structures, either in the form of diversion structures or hard points such as stairs and bridge pilings, also decrease levels of complexity and potential for channel migration, although their impact is minimal compared to traditional armoring due to shear differences in length/impacted area. Armoring is particularly pervasive in riverscapes 40-44 (Figure 9-1), where 25-40% of the channel length is reinforced via a variety of mechanisms: traditional riprap using large rocks, placement of a mélange of concrete debris, or, on occasion, "Detroit riprap" – the lining of riverbanks with old automobiles and appliances (Appendix A, Photo A-43). In-bank structures related to recreational and City development are also prevalent through these reaches (Figure 9-2). The occurrence of relatively more extensive bank reinforcement in these riverscapes is expected given the proximity to the City of Steamboat Springs and related infrastructure.

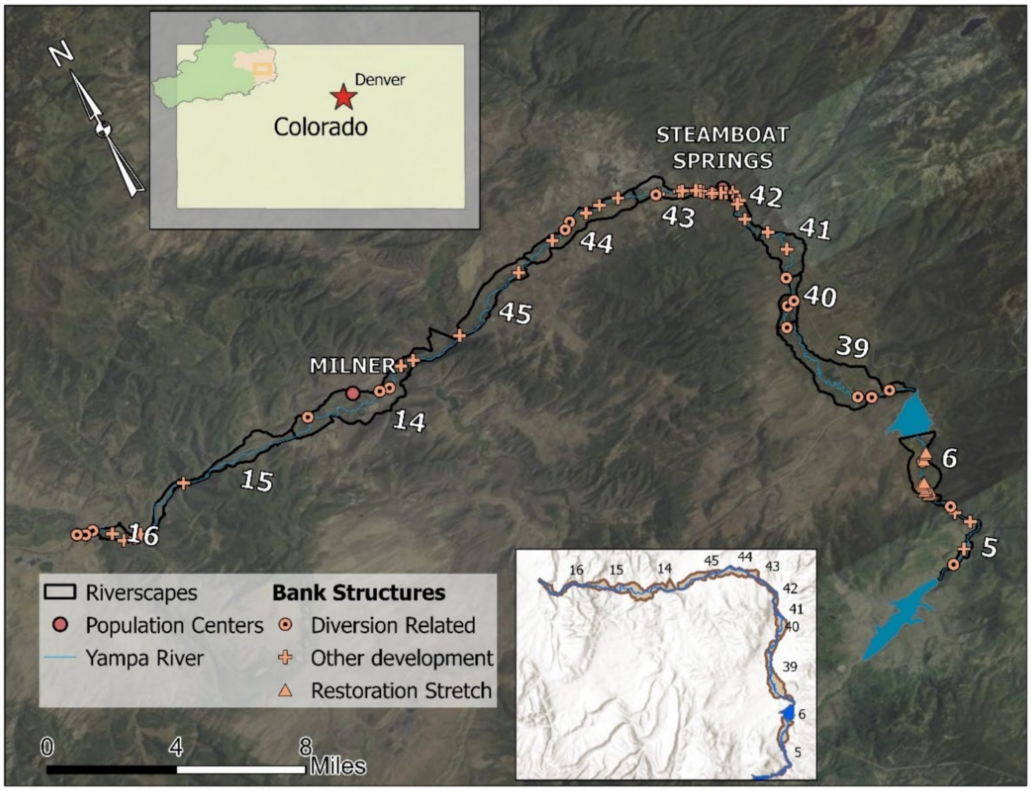
Figure 9-1. Bank Armoring Across the Middle Yampa Segment by Riverscape



Moderate armoring and presence of bank structures occur in riverscape 39 upstream of the City, as well as riverscapes 45, 14, 15, and 16 downstream of the City, though with much greater lengths of channel between armored sections (Figure 9-1). Higher frequencies of diversion-related structures are also found, rather than development-related hard points, due to the transition into more agricultural land uses (Figure 9-2; Appendix A, Photos A-44 and A-45). In contrast, riverscapes 5 and 6 are notably lightly armored; again, this is expected given the distance from any substantial development. However, the prevalence of restoration-related bank structures increases significantly in riverscape 6 (Figure 9-2). Restoration actions taken to improve bank stability and fish habitat utilized copious amounts of root boles, logs, and rock, which were then buried into the banks throughout most of the riverscape, creating hardened banks and limiting lateral mobility (Appendix A, Photos A-37 through A-40).

Likely as a function of moderately light armoring, riverscapes 45, 14, 15, and 16 also have extensive occurrences of features indicative of complexity such as backwaters and side channels/split flows (Figure 5-3; Appendix A, Photos A-35, A-36, and A-23 through A-27). As mentioned above, this may result from the additional "freedom" of the river to migrate across the floodplain in these sparsely armored reaches. Interestingly, despite the fairly frequent occurrence of armoring in riverscape 41, complexity features are somewhat abundant; this is perhaps due to the preservation of the natural floodplain ecosystem in many areas. Relatedly, there is relatively extensive occurrence of large wood (Figure 9-3; Appendix A, Photos A-17 and A-18) and bar surfaces (Figure 9-4; Appendix A, Photos A-21 and A-22) in riverscape 41, both indicators of more natural riverine complexity.

Figure 9-2. In-Bank Structures by Type and Riverscape



Wood and bar surfaces are additionally extensive in riverscapes 39 and 44, and moderately so in riverscapes 45, 14, 15, and 16. The latter riverscapes show higher frequencies of large wood pieces, but relatively balanced distributions of bars indicative of a well-functioning system (Figure 9-4). Wood is also found extensively throughout riverscape 5 and through the City of Steamboat Springs (Figure 9-3), but due to the size of the pieces (primarily medium to small), the influence on development of complexity is diminished (Figure 9-4; Appendix A, Photos A-46 and A-47). In contrast, signs of beaver activity are frequent in the City riverscapes and are comparatively light or absent throughout the other riverscapes (Figure 9-5). This discrepancy may be due to the City's frequent management of their recreational areas adjacent to the river providing a consistent source of food when other riverscapes exhibit heavier riparian impacts. It is also possible that this is the result of a sampling bias because much of the town reaches were hiked to collect observations rather than floated, allowing for ample time to take note of beaver sign, such as chewed branches (Appendix A, Photo A-48). Scores for the macrohabitat in each riverscape are provided in Table 9-2.

Figure 9-3. Locations of Woody Material by Riverscape

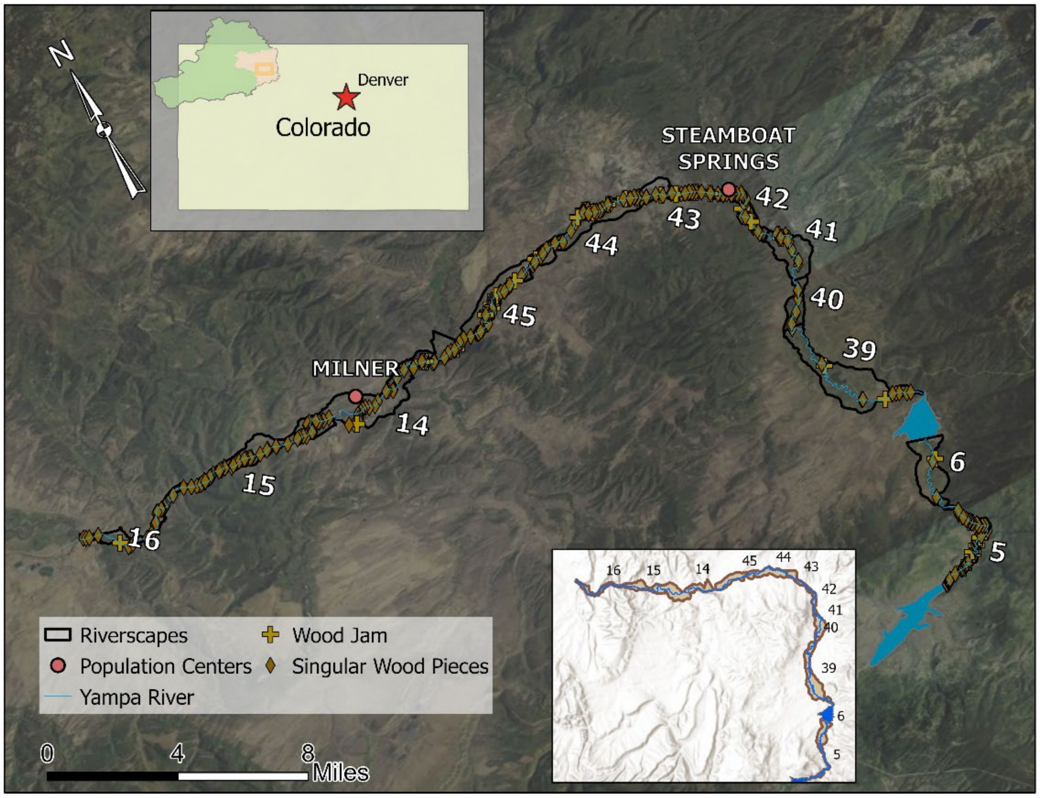


Figure 9-4. Locations of Bar Features by Riverscape

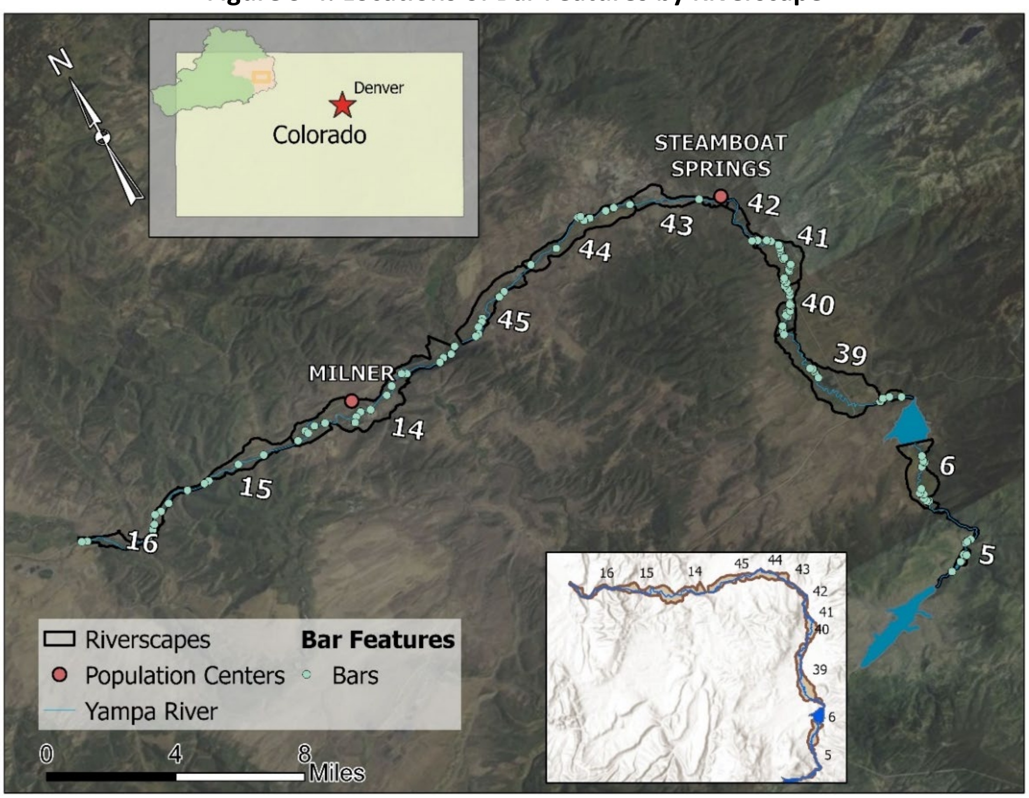


Figure 9-5. Beaver Sign by Riverscape

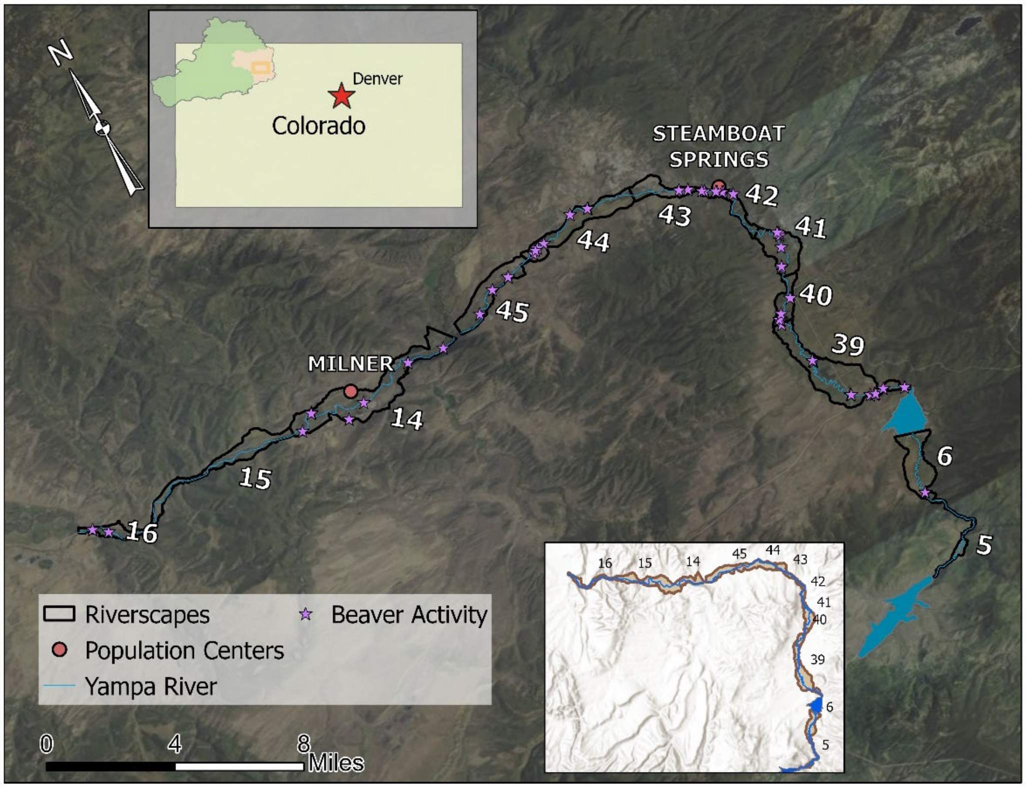


Table 9-2. Macrohabitat Scores by Riverscape

Riverscape	Macrohabitat Score
Riverscape 5	B-
Riverscape 6	C-
Riverscape 39	B
Riverscape 40	C+
Riverscape 41	B-
Riverscape 42	C
Riverscape 43	C-
Riverscape 44	B
Riverscape 45	A
Riverscape 14	A
Riverscape 15	A
Riverscape 16	A

9.2 MICROHABITAT INDICATOR

The microhabitat indicator considers physical habitat relevant to small aquatic species such as benthic macroinvertebrates and larval fish, particularly the availability of interstitial spaces among the river bed substrate, degree of embeddedness, armoring, proportion of fine sediment, algae cover, and patches of organic material or detritus accumulations.

9.2.1 Data Sources and Evaluation Methods

The microhabitat indicator is scored in the field through visual observations of embeddedness and presence/absence of algae cover. Embeddedness measures the degree to which gravel and cobble substrates are surrounded by fine sediment. It relates directly to the suitability of the stream substrate as habitat for macroinvertebrates, fish spawning, and egg incubation. Embeddedness measurements occur in riffles only. Embeddedness is measured by picking up particles of gravel or cobble with the evaluator’s fingertips at the fine sediment level. The particle is pulled out of the bed and the percent of that particle that was buried by sediment is estimated (NRCS 2017).

9.2.2 Scoring Criteria

The scoring criteria outlined in Table 9-3 based on field observations of interstitial space availability, bed armoring, embeddedness, and algae in riffles are used to rate the microhabitat indicator.

Table 9-3. Microhabitat Indicator Scoring Criteria

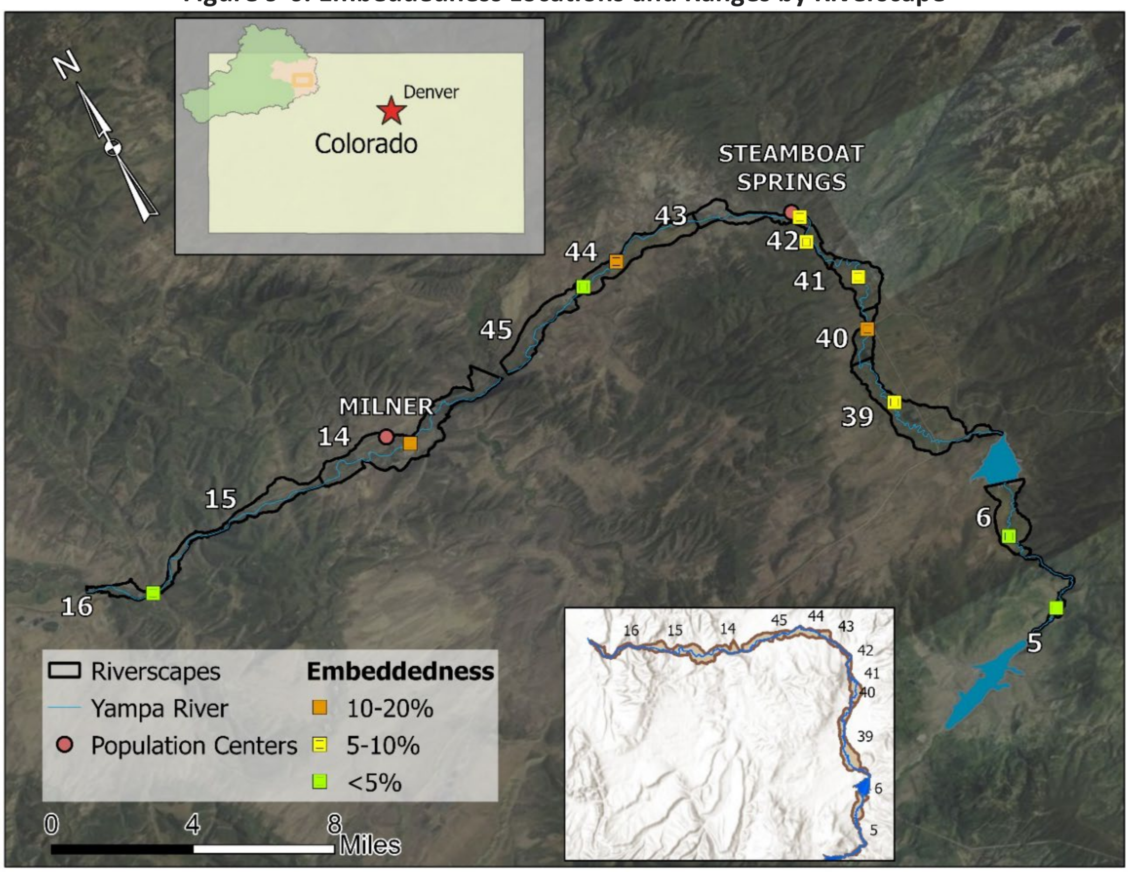
Grade	Description
A	Micro-scale structural heterogeneity is natural and appropriate for a well-functioning river in its process-domain. Interstitial spaces appropriate for natural geographic conditions.
B	All aspects of micro-scale structural diversity are present, but distribution of features is skewed due to dispersed stressors or minimal direct impacts. Examples include reaches with mild fine sediment deposition or slightly decreased interstitial space (mild embeddedness, 10-20%) for either cobble- or gravel-bed reaches, depending on natural geographic conditions.
C	Some aspects of micro-scale structural diversity are lacking or limited. Examples include reaches with altered bed material distribution, patches of armoring, increased cover of persistent algae/aquatic vegetation, decreased detritus/organic accumulation patches, or moderate embeddedness (20-30%) for either cobble- or gravel-bed reaches, depending on natural geographic conditions.
D	Some aspects of micro-scale structural diversity are lacking or severely limited, making the reach uncharacteristically homogeneous. Examples include reaches with widespread armoring, persistent algae/aquatic vegetation in riffles, lack of any detritus/organic accumulation patches, or severe embeddedness (30-40%) for either cobble- or gravel-bed reaches, depending on natural geographic conditions.
F	Completely static or homogeneous armored micro-scale physical structure. Examples include gravel- or cobble-bed streams that are aggrading with fine material (embeddedness >40%) or choked with algae, alluvial streams unnecessarily scoured to bedrock, or grouted/hardened artificial streambeds.

9.2.3 Results

Data to score this indicator were collected via field visits to illustrative locations with reliable access in each riverscape and observing presence/absence of algae cover, as well as evaluating embeddedness at riffles co-located with macroinvertebrate monitoring locations, plus a few additional opportunistic locations. Embeddedness is evaluated following the methodology described above.

Embeddedness was lowest (<5%) at measured riffles in riverscapes 5, 6, 45, and 16 (Figure 9-6). Low values of embeddedness in riverscapes 5 and 6 track with the proximity of these reaches to Stagecoach Reservoir, which serves as an impediment to natural sediment transport through these reaches. Higher valley confinement in reach 5 also increases transport of sediment, leading to coarser bed material overall. Relatively low embeddedness values of 5-10% were measured in riverscapes 39, 41, 42, and 43. The highest, but still relatively low, values of embeddedness were found in riverscapes 40, 44, and 14. Algal cover was not significant at any of the sampled locations, or generally observed throughout the Steamboat segment during 2023 fieldwork across a range of flow conditions. These observations contrast with algal cover conditions observed during 2022 fieldwork for the Middle Yampa segment at locations within both the Steamboat and Middle Yampa segments, when algae was much more prevalent.

Figure 9-6. Embeddedness Locations and Ranges by Riverscape



Overall, values of embeddedness were within the range of expected variability, despite the higher anthropogenic influences of the town of Steamboat Springs, which illustrates possible balance between agricultural land, developed land, and recreational lands in these reaches. These lower values could also be due to the higher than usual flows experienced during spring runoff during the 2023 water year and subsequent flushing flows throughout the summer. The low to moderate percentages indicate a healthy relationship between deposition and transport through these reaches. Scores for the microhabitat indicator are presented in Table 9-4.

Table 9-4. Microhabitat Scores by Riverscape

Riverscape	Microhabitat Score
Riverscape 5	A
Riverscape 6	A
Riverscape 39	A
Riverscape 40	B+
Riverscape 41	A
Riverscape 42	A
Riverscape 43	A
Riverscape 44	B+
Riverscape 45	A
Riverscape 14	B+
Riverscape 15	A
Riverscape 16	A

10.0 BIOTIC COMMUNITY

Biotic community is defined as the health of resident aquatic biota including microbes, periphyton (attached algae), macrophytes (aquatic plants), macroinvertebrates (aquatic insects), fish, amphibians, and any other organism that is part of the aquatic biological community for all or part of its life history. There are two indicators within the biotic community category: **macroinvertebrates** and **native fish**. The final biotic community score is calculated as an average of the macroinvertebrates and native fish indicator scores. Information about sport fish is covered in the River Uses and Management attribute of the Scorecard.

10.1 MACROINVERTEBRATES INDICATOR

Benthic macroinvertebrates can be used as indicators of both water quality and the health of the biotic community. Refer to Section 4.4 for details and scores related to this indicator.

10.2 NATIVE FISH INDICATOR

Fish population monitoring, typically conducted via electrofishing surveys, is used to determine fish species composition (including relative abundances of species), density estimates, age or size class distribution, and other metrics related to the health of the fishery. Due to the paucity of comprehensive data in the Steamboat segment, the native fish indicator is focused on percent native fish and presence of Mountain Whitefish and the “Three Species.” The “Three Species” are Bluehead Sucker, Flannelmouth Sucker, and Roundtail Chub. These species are not currently listed under the ESA, but they are imperiled throughout their collective geographic range due to habitat loss and interactions with nonnative species.

10.2.1 Data Sources and Evaluation Methods

Many of the fish electroshocking efforts in this region, particularly those conducted by US Fish and Wildlife Service (USFWS), have been motivated by invasive species removal (for species such as Northern Pike, Smallmouth Bass, and White Sucker). While a range of historical data exist for the riverscapes in the Steamboat segment, it is important to consider that these data are more focused on non-native fish removal efforts, and are therefore biased to record those species more frequently instead of providing some estimation of species abundance and diversity. Importantly, even though data collected through nonnative removal efforts are biased to identify and record nonnative species, a lack of native species even caught by chance during those efforts reveals information about local fish populations.

Population data have still been collected at each riverscape in the Steamboat segment except riverscape 45 between one and 22 times over the years 1955 to 2022. The most consistent and comprehensive data collection efforts have occurred in riverscapes 5, 42, and 43. The remaining riverscapes had limited data available for review; therefore, a low level of confidence is associated with scores from all riverscapes except riverscape 5, 42, and 43.

10.2.2 Scoring Criteria

The scoring criteria outlined in Table 10-1 based on presence and proportions of native species are used to rate the native fish indicator. This scoring scheme is based on the fisheries evaluation conducted for the Yampa IWMP remote assessment (Yampa IWMP 2021). It acknowledges that nearly all of the Yampa's riverscapes contain impacted fisheries; any riverscapes that earn an "A" grade are still highly modified compared to historical conditions. However, the goal of this scoring system is to differentiate between riverscapes on a relative scale. Had the historical condition of robust, native fisheries been used for the "A" grade, no differentiation would be possible, because all riverscapes would have low scores. The use of an altered baseline condition allows the prioritization of riverscapes and the opportunity to select individual riverscapes for future adaptive management and research activities. In transitional riverscapes, the fish community is composed of coldwater and warmwater species, and the scoring is adjusted to reflect this. For example, a small proportion of salmonids does not indicate impairment in riverscapes in the transitional Scorecard focal segment (Yampa IWMP 2021).

Table 10-1. Native Fish Indicator Scoring Criteria

Grade	Description
A	The reach supports all of the expected native species for the given watershed location. In coldwater riverscapes, Colorado River Cutthroat Trout, Mountain Whitefish, Mottled Sculpin, and Mountain Sucker are expected. In warmwater riverscapes, The Three Species (Bluehead Sucker, Flannelmouth Sucker, and Roundtail Chub), Mountain Sucker, Colorado Pikeminnow, and Speckled Dace are expected. Nonnative species such as Northern Pike, Smallmouth Bass, and White Sucker are not common. The percentage of native species is generally greater than 50%.
B	The reach supports a majority of the expected native species for the given watershed location. In coldwater riverscapes, Colorado River Cutthroat Trout, Mountain Whitefish, Mottled Sculpin, and Mountain Sucker could be expected. In warmwater riverscapes, The Three Species (Bluehead Sucker, Flannelmouth Sucker, and Roundtail Chub), Mountain Sucker, Colorado Pikeminnow, and Speckled Dace are expected. Nonnative species such as Northern Pike, Smallmouth Bass, and White Sucker are present but not common. The percentage of native species is generally greater than 20%.
C	The reach supports some expected native species for the given watershed location. In coldwater riverscapes, some or all of the native salmonids may have been replaced with Brook Trout, Brown Trout, and/or Rainbow Trout, but the naturalized populations are robust. Mottled Sculpin are expected. In warmwater riverscapes, some of the native warmwater species listed above are present. Mottled Sculpin and Speckled Dace are also expected. Nonnative species are common, and native species comprise 10-20% of the fish community.
D	The reach supports few or no native fish, or the fishery exhibits a highly degraded condition. In coldwater systems, salmonids are expected, but in low densities. Mottled Sculpin or Speckled Dace may be present. In warmwater riverscapes, The Three Species (Bluehead Sucker, Flannelmouth Sucker, and Roundtail Chub), Mountain Sucker, and Colorado Pikeminnow are largely or entirely absent. Speckled Dace may be the only native warmwater species present. Nonnative

	species are common and abundant. Native species comprise less than 10% of the fish community.
F	The reach does not support native fish, and/or the fishery exhibits a highly degraded condition. In coldwater systems, salmonids are absent or present in low densities, and Mottled Sculpin and Speckled Dace are absent. In warmwater riverscapes, The Three Species (Bluehead Sucker, Flannelmouth Sucker, and Roundtail Chub), Mountain Sucker, and Colorado Pikeminnow are absent. Nonnative species dominate, and native species comprise less than 5% of the fish community.

10.2.3 Results

Results for the native fish indicator are provided in Table 10-2 and described here. Unfortunately, no data are available for riverscape 45, and riverscapes 41 and 14 were only sampled once. Riverscape 41 was visited in 2003 for a Northern Pike removal effort that yielded 77 of the nonnatives and did not list observations of any other species. The CPW database record from riverscape 14 shows a single Cutthroat Trout caught in 1976. Riverscape 15 is also not scored, as all surveys conducted have been for nonnative fish removal.

In the vicinity of riverscapes 5 and 6, located between Stagecoach Reservoir and Lake Catamount, CPW stocking reports show stocking of tens of thousands of Rainbow Trout in that area almost every year since the 1970s, as well as some instances of stocking of Brook Trout, Brown Trout, and Snake River Cutthroat Trout (1993 only). Riverscapes 39 through 45 (below Lake Catamount and through the City of Steamboat Springs to the Elk River confluence) were stocked with hundreds of thousands of Rainbow Trout, Brown Trout, and Cutthroat Trout between 1973 and 2022, as well as thousands of native Bluehead Sucker between 2015 and 2019. Below the Elk River confluence (riverscapes 14 through 16), stocking efforts from the 1970s through 2020 have been exclusively Rainbow Trout, Brown Trout, and Cutthroat Trout, but in 2020-2022 these efforts have also included non-game native fish (Bluehead Sucker and Flannelmouth Sucker).

Riverscape 5 had some amount of data collected in 1955, 1976, 1979, 1994, 1995, 1998, and every year between 2000 and 2020 except 2004, 2005, 2009, and 2013. Over those years, 14 different species of fish were observed. Species caught are almost all nonnatives, except Mottled Sculpin and Speckled Dace reported most years starting in 1994 and Mountain Whitefish reported almost every year since 1955. All trout are nonnative Rainbow Trout, Brown Trout, Rainbow Trout, Brook Trout, plus a handful of Cutthroat Trout. Data from electroshocking monitoring events show that percentages of Mountain Whitefish compared to other fish caught have been declining over time. In the early years of survey (1955 and 1976), percentages of Mountain Whitefish caught hovered around 50%. In the 1990s and early 2000s, the percentage dropped to around 14%, and since 2006 the average percentage of Mountain Whitefish in the overall sample is 1%. Similarly, the percentage of native to nonnative species was around 50% in the early years, dropped to approximately 35% in the 1990s and early 2000s, and has averaged 12% since 2006. Based on these data, riverscape 5 earns a score of C-.

In riverscape 6, data collected near the confluence with Green Creek during 2016 and 2020 resulted in observations of 8 species: nonnative Rainbow Trout, Brook Trout, Brown Trout, White Sucker, and Longnose Dace, and native Mountain Whitefish, Mottled Sculpin, and Speckled Dace. Percentages of Mountain Whitefish captures compared to other species were 8% in 2016 and 9%

in 2020. However, Mottled Sculpin were captured in relatively high numbers, and percent native fish were 37% in 2016 and 14% in 2020, earning this riverscape a score of C.

Riverscape 39, extending from the tailwaters of Lake Catamount to CPW's Chuck Lewis State Wildlife Area, was sampled in 1955, 1976, 2001, 2003, 2004, and 2010. Species observed included 9 nonnative fish species plus a category of "other warmwater species," as well as native Mountain Whitefish, Mottled Sculpin, Speckled Dace, and 2 Bluehead Suckers caught in 2003. Percentages of Mountain Whitefish were robust in 1955 (77%) but were just 0-1% in the remaining years. Similarly, percentages of native fish were high in 1955 (77%) but much lower in the early 2000s (0-4%). Based on these data, this riverscape earns a score of D+.

The Chuck Lewis SWA comprises most of riverscape 40, where electrofishing efforts have occurred in 2000, 2003, 2016, and 2019. The purpose of the efforts in 2016 and 2019 was listed as nonnative fish removal, so quantitative data from those years is quite sparse. In 2000, predominantly nonnative White Suckers and Northern Pike were observed, as well as moderate numbers of Rainbow Trout, a couple Brown Trout, and some native Bluehead Suckers, Mountain Whitefish, Speckled Dace, and Mottled Sculpin. Although not specified in the CPW database, 2003 electroshocking efforts also appeared to be geared toward nonnative fish removal, as 347 Northern Pike were reported alongside much lower numbers of White Sucker, Rainbow Trout, Brown Trout, and Speckled Dace. For the years with available data, percentages of Mountain Whitefish are extremely low (0-1%), as are percentages of native species (0-10%). As a result, riverscape 40 earns a score of D.

Fishery monitoring efforts occurred almost every year between 1990 and 2022 in riverscape 42, though most of the efforts since 2016 have centered around nonnative species removal. A total of 12 different species have been observed over the years, including 5 native species (Mountain Whitefish, Mottled Sculpin, Speckled Dace, Flannelmouth Sucker, and Bluehead Sucker). Populations of sport fish are consistently robust, but stocking efforts have also been pervasive in this area and time period. Still, percentages of Mountain Whitefish have averaged 13% over the years, notably 17% in 2018. The percentage of native species in riverscape 42 is also comparatively high, averaging 40% over the sampling years and seeming to fluctuate based on survey purpose rather than decline over time. Based on this information, riverscape 42 earns a score of C+.

Within riverscape 43, fishery data were collected during 22 of the years between 1983 and 2021. Over those years, 14 species were observed including 4 native species (Mountain Whitefish, Mottled Sculpin, Speckled Dace, and Bluehead Sucker). Similar to riverscape 42, populations of sport fish, mainly nonnative trout, have been healthy and consistent. Mountain Whitefish populations are low but stable; percentages of Mountain Whitefish have averaged 11% over the years, but have declined noticeably from 16% prior to 1997 to 5% after 1997. Overall native fish percentages have averaged approximately 40% and have remained relatively consistent over the 40 year period. Based on these data, riverscape 43 earns a score of C+.

Although samples were collected during 4 different years at riverscape 44, only the 2016 monitoring event was not related to nonnative fish removal or tissue/genetic sampling. In 2016, Mountain Whitefish accounted for 3% of the total catch, but the percentage of native species compared to nonnatives was up to 55% due to the high numbers of Mottled Sculpin and Speckled Dace present. Based on limited data, riverscape 44 earns a score of C+.

Data collected in riverscape 16 are primarily related to nonnative fish removal (2015-2021), so this riverscape is difficult to score. Species reported are almost all nonnatives except reports in 1993 of Mountain Whitefish, Mottled Sculpin, Speckled Dace, Flannelmouth Sucker, Bluehead Sucker, and Roundtail Chub). Recent (2019-2022) anecdotal reports of fishing at the downstream end of this riverscape in TNC's Yampa River Preserve identified Northern Pike, Rainbow Trout, Brown Trout, Cuttbow Trout, and Mountain Whitefish, with trout being the most common salmonids but Mountain Whitefish also caught consistently. Anecdotal reports obviously do not account for smaller-bodied species such as sculpin and dace. Based on these data, this riverscape earns a score of D+.

It is possible that scores for some of the riverscapes would improve slightly with data collection efforts tailored toward community characterization; however, the fishery in these riverscapes is significantly impaired due to an overabundance of nonnative species. While the scores of C+ assigned to riverscapes 42, 43, and 44 still denote a very degraded condition as a result of the use of an "altered baseline condition" for this Scorecard effort to allow for the prioritization of riverscapes and the opportunity to select individual riverscapes for future adaptive management and research activities, these 3 riverscapes appear to be more successful than the other riverscapes in both the Steamboat and Middle Yampa segments at supporting populations of native fish. From a future data collection perspective, it would be informative to focus on community or population estimates at a minimum of one location within the Steamboat segment per year or every other year to limit some of the uncertainty around the state of the fishery through this segment.

Table 10-2. Native Fish Indicator Scores by Riverscape

Riverscape	Native Fish Score
Riverscape 5	C-
Riverscape 6	C
Riverscape 39	D+
Riverscape 40	D
Riverscape 41	NA
Riverscape 42	C+
Riverscape 43	C+
Riverscape 44	C+
Riverscape 45	NA
Riverscape 14	NA
Riverscape 15	NA
Riverscape 16	D+

11.0 OVERALL RIVER HEALTH AND FUNCTION SCORE

Upon assigning scores for each indicator and category to each riverscape within the Scorecard focal segment, the individual category scores are integrated to derive a final river health and function score for each of the 12 riverscapes within the 42-mile Steamboat segment of the Yampa River. The percent contributions of each river health and function category are provided in Table 11-1. A weighted average by riverscape area is then calculated to yield a final segment score for the River Health and Function attribute area.

Table 11-1. Percent Contribution to Overall River Health and Function Score by Category

Category	Percent
Flow Regime	20
Sediment Regime	5
Water Quality	15
Habitat Connectivity	5
Riverscape Connectivity	10
Riparian Condition	20
River Form	5
Structural Complexity	15
Biotic Community	5

The final river health and function scores for the Yampa River Steamboat segment are provided in Table 11-2, organized by indicator and riverscape. **Weighting the cumulative scores for each riverscape by river length yields an overall ecological health and function score of B- for the entire Yampa Steamboat segment**.

Despite flowing through the largest city on the Yampa River, the Steamboat segment boasts an impressive overall ecological health and function score of B-, a testament to its resilience and notable features of complexity. The river excels in water quality parameters, excluding temperature, but including pH, dissolved oxygen (DO), nutrients, and metals, underscoring the river's health and ability to transfer nutrients throughout the system. As recognized in the Yampa River Health Assessment and Streamflow Management Plan (City of Steamboat Springs 2018), elevated river temperatures remain a concern and a top priority. As a result, various entities are actively addressing high temperatures through multifaceted approaches, reflecting a collective commitment to understanding and improvement.

Active seasonal management of flows through Stagecoach Reservoir and Lake Catamount in the Steamboat segment yields positive outcomes reflected in relatively high scores in the hydrograph metrics. Despite the presence of these reservoirs, the strategic implementation of this approach, which attempts to match outflow through the reservoirs to that of the incoming flow upstream, maintains a more natural flow regime, mitigating potential ecological impacts. This approach minimizes alterations to the river's hydrological patterns, allowing for flushing flows that contribute to the preservation of channel morphology and promote optimal riparian conditions wherever possible. Additional releases of stored water from Stagecoach Reservoir during periods of low base flow also mitigate ecological impacts resulting from higher temperatures and loss of riparian habitat. Consequently, the positive influence on the hydrograph metrics extends to other ecological parameters, resulting in an overall improvement in the river's health and function scores.

Riverscape connectivity and channel morphology emerge as key areas where opportunities for enhancements are abundant. The upper reaches and those flowing through the City of Steamboat Springs face the greatest challenges with connectivity to the available floodplain, which in turn limits the ability of the river to develop appropriate morphological features. Despite these challenges, structural complexity and aquatic habitat throughout the Steamboat segment remain intact where possible, with higher than expected availability of secondary habitat, wood, and complex bedforms, especially in the lower reaches.

Riparian condition scores also leave room for improvement and scored lowest through the City reaches due to increased level of development and land use changes. However, potential for significant improvement exists particularly in the upper reaches, in partnership with interested landowners. Through collaboration, initiatives to enhance floodplain connectivity and restore the natural sediment regime could positively influence riparian health quickly and effectively. Facilitating increased riverine spatial dynamics by allowing for lateral expansion and longitudinal movement can concurrently enhance riparian health and yield positive ramifications for the fishery, and focusing on the upper reaches can drive positive changes throughout the entire river system.

Patterns across riverscapes in the Steamboat segment reveal that areas with minimal alterations to the floodplain or land preservation status exhibit better river health. Conversely, opportunities for improvement are identified in riverscapes hosting major towns and higher levels of agricultural development, emphasizing the need for balance between development and environmental conservation efforts. In conclusion, the Steamboat segment stands out as relatively healthy, with ongoing initiatives and collaborative projects actively addressing identified challenges. The Yampa River, compared favorably to its counterparts in Colorado and the broader Colorado River Basin, still holds the potential to become a flagship for riverine health. Engaging with the ongoing Yampa River Scorecard Project at https://yampascorecard.org/ provides a comprehensive understanding of the current state of the river and encourages active participation in its sustainable future.

Table 11-2. Steamboat Segment Ecological Health and Function Scores by Indicator and Riverscape

	Segment		Yampa River Steamboat Segment												
	Riverscape		5	6	39	40	41	42	43	44	45	14	15	16	Overall
	Length (miles)		4.02	3.03	6.28	1.65	2.85	1.81	2.47	3.66	2.97	5.95	2.63	4.52	
	Riverscape Area (square miles)		0.26	1.3	2.34	0.5	0.98	0.33	0.74	1.38	1.2	2.89	0.83	0.76	
Category	**Indicator**	**Scoring Weight**													
Flow Regime	Hydrograph		C+	B-	C+	C+	B	B	B-	B-	B-	A	A	A-	B
	Snowpack		B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-
	Flow Regime	**20%**	C+	C+	B-	B+	B+	B+	B	B	B	B	B	B	B
Sediment Regime	**Sediment Transport and Continuity**	**5%**	B-	C+	C+	C-	C-	D	D-	A-	A-	A	B	B+	B-
Water Quality	Temperature		D	D	D	D	D	D	D	D	D	D	D	D	D
	Dissolved Oxygen		A	A	A	A	A	A	A	A	A	A	A	A	A
	pH		A-	A-	A-	A	A	A	A	B+	B+	B+	B+	B+	A-
	Macroinvertebrates		C+	B+	C+	C+	B+	B	B	B+	B-	B+	B+	B-	B
	Nutrients		A	A	A	A	A	A	A	A	A	A	A	A	A
	Metals		A	A	A	A	A	A	A	A	A	A	A	A	A
	Water Quality	**15%**	B+	B+	B+	B+	B+	B+	B+	B+	B+	B+	B+	B+	B+
Habitat Connectivity	Aquatic Habitat Connectivity		C+	C-	B+	C+	A	B	B-	A	A	A-	A-	A-	B+
	Terrestrial Habitat Connectivity		A	A	C+	C+	C+	C	D-	C+	C+	C+	C+	B	B-
	Habitat Connectivity	**5%**	B+	B	B	C+	B+	B-	C-	B+	B+	B	B	B+	B
Riverscape Connectivity	**Riverscape Connectivity**	**10%**	C-	D-	D	D	C	C	F	B-	B	A	C+	B	C
Riparian Condition	Vegetation Structure and Complexity		C+	C+	C	C+	C+	C-	D	C+	B-	B-	B-	B-	C+
	Invasive Species		A	A	A	A	A	A	A	A	A	A	A	A	A
	Riparian Condition	**20%**	B-	B-	C+	B-	C+	C	D+	C+	B-	B	B	B	C+
River Form	**Channel Morphology**	**5%**	C	B	C+	C+	C+	D+	D+	B-	B-	B+	B-	B-	C+
Structural Complexity	Macrohabitat		B-	C-	B	C+	B-	C	C-	B+	A	A	A	A	B
	Microhabitat		A	A	A	B+	A	A	A	B+	A	B+	A	A	A
	Structural Complexity	**15%**	B	C+	B+	B-	B	B-	C+	B	A	A	A	A	B
Biotic Community	Macroinvertebrates		C+	B+	C+	C+	B+	B	B	B	B-	B+	B	B-	B
	Native Fish		C-	C	D+	D	N/A	C+	C+	C+	N/A	N/A	N/A	D+	C-
	Biotic Community	**5%**	C	B-	C-	C-	B+	B-	B-	B-	B-	B+	B	C	B-
	Weighted River Health Score	**100%**	B-	B-	C+	C+	B	C+	C	B	B	A-	B+	B+	B-

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APPENDIX A

PHOTO COMPILATION

Photo A-1. Minor erosion indicative of a healthy river.

Photo A-2. Minor erosion indicative of a healthy river.

Photo A-3. Minor erosion indicative of a healthy river.

Photo A-4. Minor erosion indicative of a healthy river.

Photo A-5. Cobble and boulder armor placed along outside bank for stabilization.

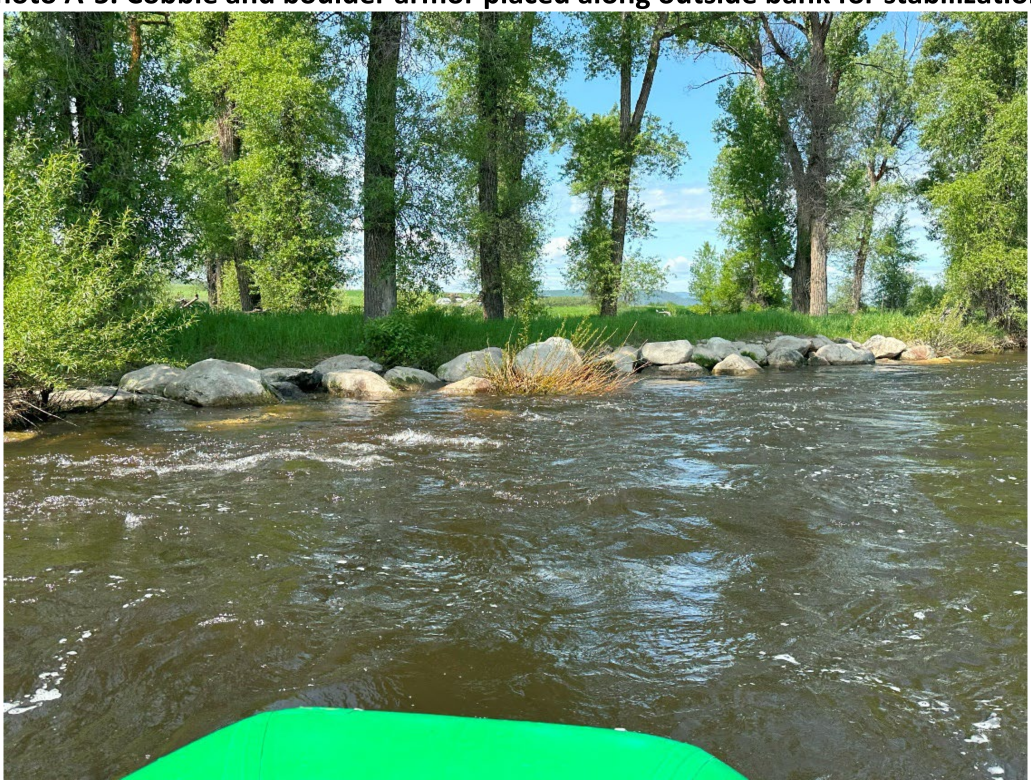

Photo A-6. Boulder armor placed for bank protection.

Photo A-7. Boulder armor placed for bank and bridge protection.

Photo A-8. Large boulder armor placed for housing protection.

Photo A-9. In-channel cross-vane intended to control flow and limit erosion.

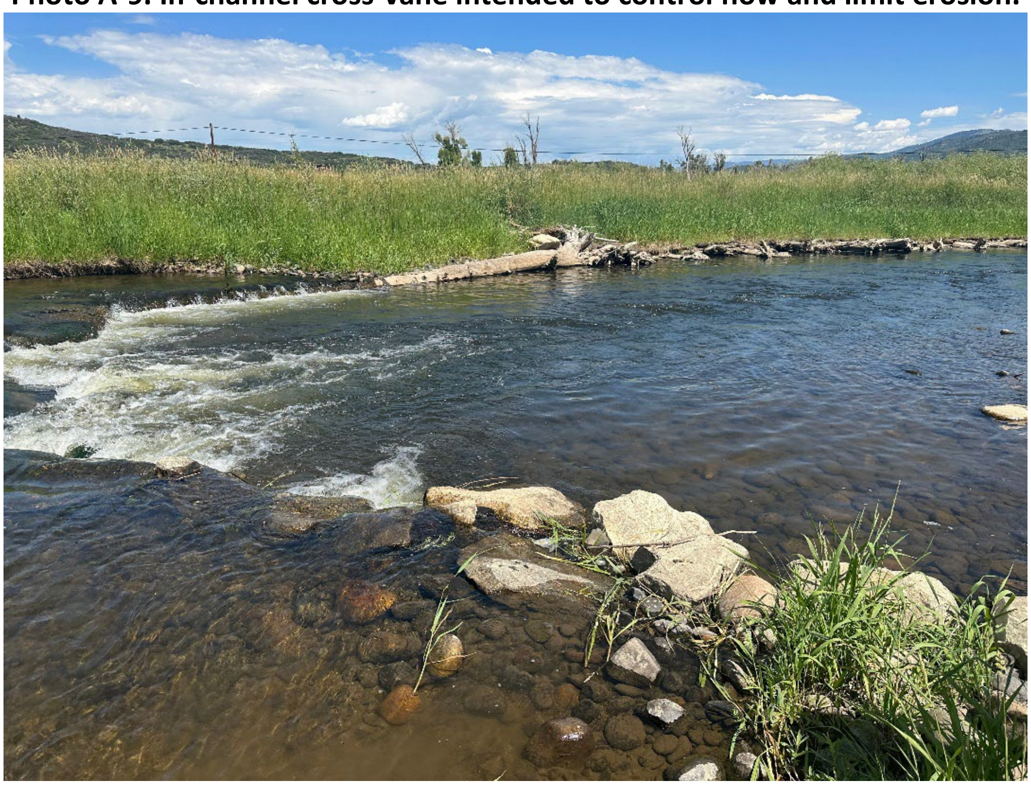

Photo A-10. In-channel cross-vane and adjoining sill-logs intended to control flow and limit erosion.

Photo A-11. Channel spanning structure intended to control flow for diversion.

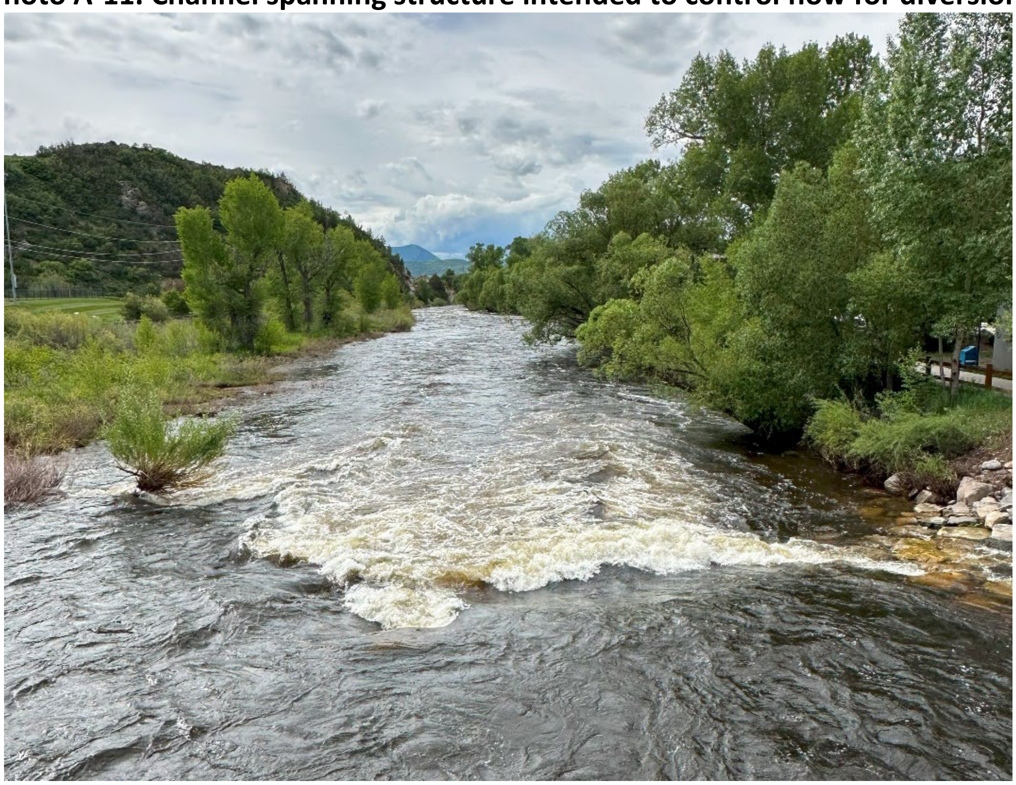

Photo A-12. Channel spanning placed boulders intended to control flow and to provide recreational opportunity; right and left bank are also manipulated and straightened with armor for roads and bike paths.

Photo A-13. Series of small cross-vane structures placed throughout fishing access point below Stagecoach Reservoir.

Photo A-14. Placed boulders below Sarvis Creek in confined portion of Riverscape 5.

Photo A-15. Confluence of Yampa River and Morrison Creek during high flow in 2023 showing high level of turbidity in Morrison Creek.

Photo A-16. Mixing point of turbid Morrison Creek contribution with the Yampa River during high flow 2023.

Photo A-17. Example of floodplain wood accumulations.

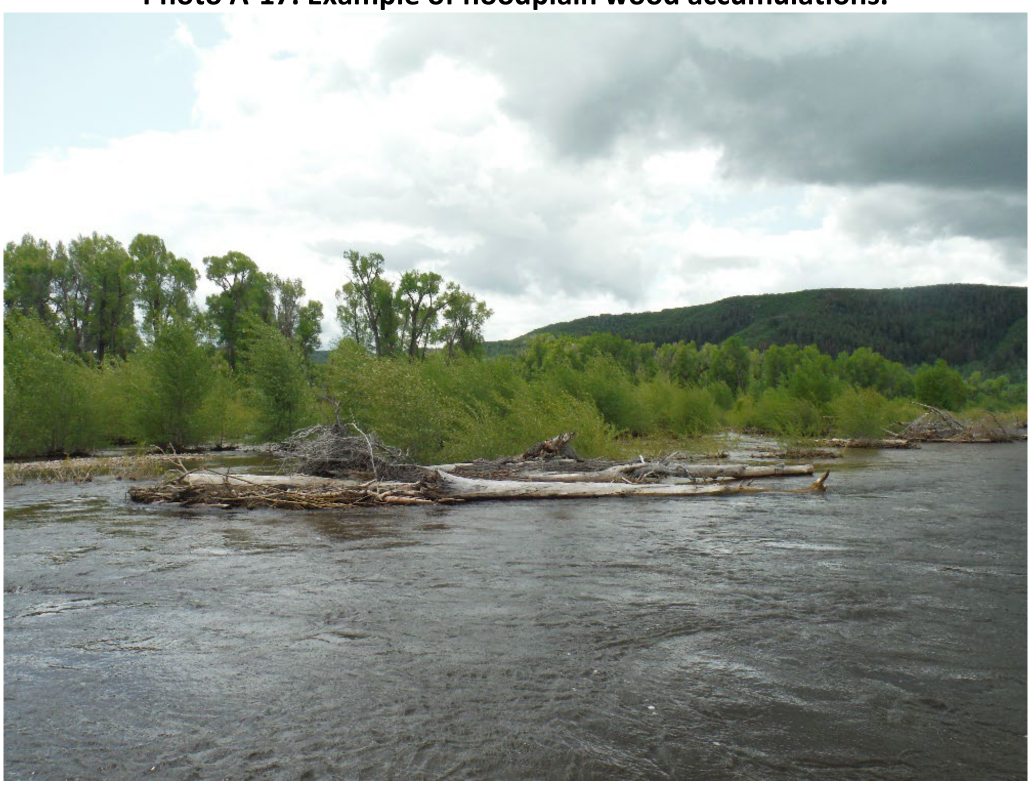

Photo A-18. Example of in-channel wood accumulations.

Photo A-19. Beaver chew on large cottonwoods.

Photo A-20. Beaver bank-lodge during high flow.

Photo A-21. Example of gravel/cobble bar indicative of healthy depositional processes.

Photo A-22. Example of gravel/cobble bar indicative of healthy depositional processes.

Photo A-23. Example of small mid-channel vegetated island.

Photo A-24. Example of small mid-channel vegetated island.

Photo A-25. Example of a side-channel feature which provides secondary habitat.

Photo A-26. Example of a side-channel feature which provides secondary habitat.

Photo A-27. Example of split flow which provides complexity.

Photo A-28. Roadway and bridge armoring.

Photo A-29. Railroad infrastructure.

Photo A-30. Armoring and retaining wall for roadway above river.

Photo A-31. Bridge infrastructure.

Photo A-32. Channel-spanning structure at low flow remains passable by aquatic organisms.

Photo A-34. Example of recreational boaters using channel-spanning structures in the City of Steamboat Springs.

Photo A-35. Example of backwater area which provides secondary habitat.

Photo A-36. Example of backwater area which provides secondary habitat.

Photo A-37. Example of restoration actions using root-wrap (buried logs).

Photo A-38. Example of restoration actions using boulders and logs.

Photo A-39. Example of restoration actions using boulders and logs

Photo A-40. Example of restoration actions using root-wrap (buried logs).

Photo A-41. Example of actively collapsing bank.

Photo A-42. Actively collapsing banks with limited riparian vegetation and evidence of cattle trampling in the foreground.

Photo A-43. Example of “Detroit” rip-rap using automobiles and other appliances.

Photo A-44. Example of diversion related bank structure.

Photo A-45. Example of diversion related bank structure.

Photo A-46. Example of small wood accumulations.

Photo A-47. Example of small wood accumulations.

Photo A-48. Example of beaver chew.

APPENDIX B

TECHNICAL MEMORANDUM: YAMPA SCORECARD STEAMBOAT SEGMENT RIPARIAN MAPPING METHODS AND RESULTS (NOVEMBER 13, 2023)