

# **FAITH VALLEY MEADOW RESTORATION POST-PROJECT MONITORING REPORT 2016-2024 FIELD SEASONS**

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## Purpose and Goals

The goal of the Faith Valley Meadow Restoration Project is to maintain and restore the hydrological and ecosystem processes at Faith Valley to enhance their ability to provide outstanding natural benefits including groundwater storage in a headwaters area, increased streamflow in the dry season, improved downstream water quality, enhanced critical habitat for threatened and sensitive native species, carbon sequestration, resilience to climate change and recreational values. The primary design objective of the project is to reduce or reverse channel incision in Faith Valley, with the expectation that the detrimental effects of incision will also be remedied. A secondary design objective is to reduce the adverse impacts of recreation on the meadow, while maintaining or improving recreational access. The purpose of project monitoring is to quantify project performance toward achieving project goals and objectives.

## Background and Schedule

American Rivers received funding from the National Fish and Wildlife Foundation (NFWF) and the California Department of Fish and Wildlife (CDFW) Watershed Restoration Grant Program to complete assessment, restoration design and permitting for Faith Valley meadow. The project area includes 120 acres of Faith Valley Meadow. Waterways Consulting completed a detailed baseline assessment of the meadow in 2018 and developed conceptual designs in 2019. The CDFW and NFWF planning grants performance period included the 2019 and 2020 field seasons. The project team established pre-project monitoring (except GHG monitoring due to funding) during or prior to the 2019 field season (generally May through November of each year depending on snow). We established GHG monitoring during the 2021 field season. The project was designed to proceed as two phases over two construction seasons in 2021 and 2022, to install a pilot set of beaver dam analogs (BDAs) the first season and evaluate performance before installing additional BDAs the second season. However, construction in 2021 had to be delayed to 2022 due to closures and safety concerns associated with the Caldor Fire. We also originally planned to implement activities in the furthest upstream reach but ultimately determined not to based on less degraded conditions and access considerations. Thus, monitoring in this reach acts as a control for the treatment reaches.

We implemented the first phase of construction from August 22 – October 5, 2022 (Appendix A: Faith Valley As-Built Drawing 2022-2023). Construction involving equipment and dewatering was completed September 13. Hand labor continued through October 5. The project installed the grade control structure, reinforcement of an existing beaver dam, and the posts for 14 beaver dam analogs (BDAs). The project team completed the willow weave on 12 of the 14 structures in 2022. Two were not completed due to time and capacity constraints. We installed a suite of slightly different structures in 2022 to be able to observe and learn from them to inform the installation of additional features in 2023. We constructed four starter dams that are more impermeable, and 8 post-line with willow weave (PLWW) BDA features that are more permeable. We planned to install the pilot set of BDAs just upstream of the grade control structure, but augmented this plan due to avoid disturbing a large, persistent natural beaver dam in that reach that was creating floodplain connection and saturated conditions. Monitoring indicated that 12 features from 2022 suffered damage during the exceptionally high winter/spring flows of 2023 but were still affecting the channel locally.

We implemented the second phase of construction August 14 – October 19, 2023, which included installing new BDAs, repairing BDAs from the 2022 season, and implementing the road repairs (Appendix A). The BDA posts were installed August 22 - September 9. The BDA weave occurred September 4 –

October 19. The project constructed 25 new BDAs and repaired 4 BDAs from the 2022 season. In some instances, damage to the 2022 BDAs created scour pools, so it was better to install a new feature adjacent to the feature than repair the original feature. We completed the weave on all but one of the new structures. All structures constructed in 2023 were a hybrid between starter dams and PLWW, designed to pond water immediately. The road repairs were implemented September 5 – 29.

We implemented a subsequent season of adaptive management actions August 19 – September 21, 2024 (Appendix A.1: Faith Valley As-Built Drawings Adaptive Management 2024). This work included implementing repairs and improvements to 29 previously installed BDA structures, installing 3 new BDA structures, and small repair work to extend the berm at one of the previously installed rocked ford structures on the dirt road adjacent to the meadow. All work in the 2024 season was completed with hand labor only. Generally, BDA features installed and repaired in 2023 performed well through the 2023-2024 winter/spring, and mostly small-scale adaptive management was warranted for repairs and to improve performance through the 2024-2025 wet season. Two features of the 12 series required more significant repairs. Repairs included installing additional 4-inch posts and repairing and extending the willow weave. In 2024, we installed 2 new structures with willow weave and one with only posts. This season all structures were built as a hybrid between post-line with willow weave and starter dams, designed to pond water immediately.

We conducted initial post-2022 and additional pre-2023 implementation monitoring through August 2023, and limited post-2023 implementation monitoring following construction through October 2023. We conducted the first season of post-project monitoring following full project implementation in 2024. Based on extended WCB grant funds, we were able to delay a suite of costly, one-time post-project monitoring until 2024 to better capture the effects of the full project implementation. However, these assessments only capture one season post-project, when certain parameters may take multiple seasons to show robust change. Due to the long time elapsed between pre-project assessments and final implementation, Overlin's vegetation mapping could not be completed post-project, as the consultant no longer works as a botanist and left the state.

## Objectives, Performance Measures, Metrics and Monitoring Methods

The table below presents the objectives and performance measures from the grant monitoring plan and the metrics and monitoring methods identified to quantify them. Where relevant, we have included additions and refinements (e.g. based on project design updates, permit requirements, etc.) in *italics*. We have updated the table to include performance measure tracking through the 2024 season.

Table 1: Objectives, Performance Measures, Metric and Monitoring Methods

| Objectives                             | Outcome Performance Measures                             | Output Performance Measures                                                                                 | Metrics                                         | Monitoring Method(s)                                                                                  | 2024 Performance Measure Results                                                                                                                                                                                                                                                                                                                                                                 |
|----------------------------------------|----------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|-------------------------------------------------|-------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Restore meadow floodplain connectivity | Channel incision reduced or reversed on 5000 linear feet | Reduced elevation difference between bankfull channel elevation and historic floodplain on 5000 linear feet | Elevation data                                  | Topographic survey; <i>TU meadow instream habitat protocol</i>                                        | Longitudinal profiles: decreased difference between estimated low flow water elevation relative to bank height (~0.5-2 ft) throughout the reach with BDAs (~4500 ft).<br>TU protocol: elevation of historic floodplain above bankfull indicator reduced in each of the 3 implementation reaches (totaling 7023 ft).                                                                              |
|                                        |                                                          | Stream channel aggraded where currently incised on 5000 linear feet                                         | Elevation data                                  | Topographic survey; <i>Beaver dam inventory</i>                                                       | Cross-sections: 1 cross section with substantial aggradation and 2 with small aggradation within the surveyed reach (~5700 ft), demonstrating a trend toward aggregation, but additional seasons of data needed to observe change. Beaver dam monitoring does not demonstrate aggregation, likely because aggregation will take longer to observe and due to issues with this pilot methodology. |
|                                        |                                                          | Increased persistence of beaver dams/grade control features at 2 locations                                  | Number and size of dam/grade control structures | Beaver dam inventory                                                                                  | Increased persistence of 1 feature maintaining grade (grade control structure) and trending toward increased persistence of numerous additional features throughout project. Substantial increase in annual number of beaver structures post-project compared to pre-restoration.                                                                                                                |
|                                        | Floodplain connectivity increased on 105 acres           | Increased frequency of overbank flooding on 5000 linear feet of channel                                     | Channel geometry                                | Topographic survey cross sections; photo point monitoring; <i>TU meadow instream habitat protocol</i> | Longitudinal profiles: 2 points where BDA riffle heights are within 1ft of bank height, suggesting high flows can access the floodplain at 2 points within 4500 ft reach with BDAs.<br>TU protocol: flood prone width increased in the two middle reaches where substantial BDAs were installed (5,077.7 ft of channel). Photo points visually confirm these results.                            |

|                                                                                        |                                                                                  |                                                                                                                                       |                                           |                              |                                                                                                                                                                                                                                               |
|----------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------|------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Increase meadow's water storage capacity                                               | Groundwater storage improved on 105 acres                                        | Increased groundwater table elevation (above baseline) during summer and fall months (June-November) on 105 acres                     | Depth to shallow groundwater table        | Groundwater wells            | Significant increase in average groundwater levels at middle transect (adjacent to BDAs). Levels at lower transect are mixed, affected by former large beaver dam that blew out in 2024, but elevated water table rebounded and maintained.   |
|                                                                                        | <i>Raise groundwater locally</i>                                                 | <i>Established trend toward maintaining a water table within 3 feet of the meadow surface at the middle and downstream transects.</i> | <i>Depth to shallow groundwater table</i> | <i>Groundwater wells</i>     | Downstream transect depth to water table within 3 feet post-project. Middle transect depth to water table not within 3 feet, but significantly higher than pre-restoration. Post-project results influenced slightly by 2023 high water year. |
| Reduced GHG emissions                                                                  | Carbon sequestration maintained and increased on 105 acres                       | Increased soil organic matter on 105 acres                                                                                            | <i>Change in soil carbon</i>              | GHG monitoring               | Net loss of soil carbon following restoration. Driven by duration of growing season, not effects of restoration. Additional seasons of data needed.                                                                                           |
|                                                                                        |                                                                                  | Not net loss of soil organic matter on 120 acres                                                                                      | <i>Change in soil carbon</i>              | GHG monitoring               | Net loss of soil carbon following restoration. Driven by duration of growing season. Additional seasons of data needed.                                                                                                                       |
|                                                                                        | Reduced peak fluxes of carbon dioxide on 105 acres                               | Reduced carbon dioxide flux on 105 acres                                                                                              | Carbon dioxide flux analysis              | GHG monitoring               | Net ecosystem exchange carbon dioxide flux not reduced post-restoration. Additional seasons of data needed.                                                                                                                                   |
| Augment peak and baseflows                                                             | Downstream baseflow enhanced during the dry season                               | Increased quantity of outflow (relative to inflow) during June-Nov                                                                    | Hydrograph analysis                       | Streamflow monitoring        | No strong trends observed. Restoration may have enhanced downstream baseflow based on comparison of upstream and downstream September flow volume. Over the full dry season, no trend observed.                                               |
|                                                                                        |                                                                                  | Decreased downstream temperatures during June-November (for a given water year type, relative to baseline)                            | Daily average stream temperature data     | Streamflow monitoring        | Temperatures slightly higher downstream than upstream pre- and post-restoration, but all remain below the upper range for native fish.                                                                                                        |
| <i>Evaluate the potential effect of Project features on the movement of streamflow</i> | <i>Project does not negatively effect movement of flow through project site.</i> | <i>Assess quantity and timing of streamflow upstream and downstream of Project</i>                                                    | <i>Hydrograph analysis, flow volume</i>   | <i>Streamflow monitoring</i> | Flow characteristics through the project site are similar pre- and post-restoration. The volume of flow entering and exiting the project site is similar across all years, indicating release water was not lost to the system.               |

|                                                                                   |                                                                                         |                                                                                                                                                        |                                                        |                                       |                                                                                                                                                                                                                                                                                                                               |
|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|---------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>through the project site in relation to upstream releases from Lost Lakes.</i> |                                                                                         |                                                                                                                                                        |                                                        |                                       |                                                                                                                                                                                                                                                                                                                               |
| Improve water quality                                                             | Erosion and downstream suspended sediment reduced                                       | Increased bank stability on 5000 linear feet of channel                                                                                                | Linear feet of unstable bank                           | TU meadow instream habitat protocol   | In 2 reaches with substantial BDA structures installed, the project reduced the extent of unstable banks by 921.9 ft across a combined reach length of 5077.7 ft. However, the extent of unstable banks increased by 75.13 ft in the downstream reach (1945.5 ft), likely affected by fluctuations in natural beaver dams.    |
| Improve habitat for meadow focal species and aquatics                             | 105 acres of habitat for Willow Flycatcher and other meadow focal bird species enhanced | Increased extent and duration of standing water near mature willow stands                                                                              | Percent surface water cover at bird survey stations    | IBP avian monitoring protocol         | Significant increase in standing water and overall water cover over time, but not specifically in response to restoration in 2022-2023. Most likely associated with increased beaver activity since 2010/2012 surveys.                                                                                                        |
|                                                                                   |                                                                                         | Increased willow recruitment and extent of willow cover on 105 acres                                                                                   | Extent and height of willow at bird survey stations    | IBP avian monitoring protocol         | Riparian shrub cover and willow age/height classes showed no distinct response to restoration, or pattern over time. Additional seasons needed to observe changes associated with restoration.                                                                                                                                |
|                                                                                   | Occurrence of Willow Flycatcher increased on restored site                              | Increased number of Willow Flycatcher detections                                                                                                       | Willow Flycatcher detections                           | IBP Willow Flycatcher survey protocol | First evidence of nesting in Faith Valley in 2024 since 2002. Although nesting likely failed to produce young, strong indicator of habitat improvement.                                                                                                                                                                       |
|                                                                                   | Habitat for stocked Lahontan Cutthroat Trout and other aquatic species enhanced on      | Increased spatial and temporal extent of seasonally inundated and thermally suitable habitat (ie. increase floodplain habitat) on 5000 feet of channel | Channel and floodplain width and depth characteristics | TU meadow instream habitat protocol   | Average wetted width increased in the 3 implementation reaches, (7023.2 ft of channel). Flood prone width increased in the middle two reaches where substantial BDAs were installed (5,077.7 ft of channel). Indicates a trend toward increased spatial extent of seasonally inundated habitat in the implementation reaches. |

|                                          |                                                                    |                                                                                                                                   |                                             |                                     |                                                                                                                                                                                                                                                                                                                                                                   |
|------------------------------------------|--------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|-------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                          | 5000 linear feet of stream channel                                 | Heterogeneity of aquatic habitats (eg. fast vs slow water habitats) maintained and increased on 5000 feet of channel              | Extent of different channel unit types      | TU meadow instream habitat protocol | Overall, aquatic habitat heterogeneity has decreased in the short-term (dominated by slow-water pool habitat vs fast-water riffles) in reaches with BDAs. However fast water units have been maintained at the downstream end and heterogeneity is expected to increase as floodplain connectivity associated with BDAs creates side channels and other features. |
|                                          |                                                                    | Reduce channel width and increase depth on 5000 linear feet of channel                                                            | Width to depth ratio                        | TU meadow instream habitat protocol | Average bankfull width increased at the 3 implementation reaches and decreased in upstream reach. Average bankfull depth increased in the 2 downstream reaches, especially in reach where most BDAs were installed. It decreased slightly in the 2 upstream reaches.                                                                                              |
|                                          |                                                                    | Increased escape cover habitat on 5000 linear feet of channel                                                                     | Percent understory and overstory cover      | TU meadow instream habitat protocol | Mesic understory vegetation cover changed very little. Wet understory vegetation cover increased in all reaches, which may be due to seasonal climatic conditions. No meaningful change in overstory cover. Additional seasons of data needed to show change associated with restoration.                                                                         |
| Enhance wet meadow vegetation and soils  | Maintain and increase wet meadow vegetation on 105 acres           | No net loss of functional or at-risk Carex, FACW or FAC vegetation assemblages (as mapped by Overlin) on 105 acres                | Extent of vegetation assemblages            | Vegetation mapping (by Overlin)     | Repeat monitoring not completed.                                                                                                                                                                                                                                                                                                                                  |
|                                          |                                                                    | Increased proportion of meadow mapped as Carex or FACW relative to FAC vegetation assemblages (as mapped by Overlin) on 105 acres | Extent of vegetation assemblages            | Vegetation mapping (by Overlin)     | Repeat monitoring not completed.                                                                                                                                                                                                                                                                                                                                  |
| Improve ecological condition and enhance | Overall meadow condition is improved using light-handed techniques | Landscape, hydrology, physical and biotic attributes (per CRAM) improved on 105 acres                                             | Increased attributes and overall CRAM score | CRAM: Slope Wetlands                | Overall CRAM score increased. Physical Structure and Biotic Structure increased, while Hydrology attribute decreased.                                                                                                                                                                                                                                             |

|                            |                                                                                            |                                                       |                           |                                           |                                                                                                                                                       |
|----------------------------|--------------------------------------------------------------------------------------------|-------------------------------------------------------|---------------------------|-------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
| recreational opportunities |                                                                                            | 120 acres restored/protected                          | Acres restored            | GPS measurements/<br>GIS mapping          | 100 acres restored/protected. Design refined to omit work in very upstream reach to limit disturbance.                                                |
|                            | Ability of OHV road to capture and concentrate flow is reduced                             | Road repair features that promote sheetflow installed | linear extent of features | GPS; photo point monitoring               | 1940 linear feet (0.37 miles) of road repair features installed. Photo points demonstrate road repairs are functioning to restore natural flow paths. |
|                            | Light-handed restoration becomes a model for an alternative approach to meadow restoration | 50 meadow restoration practitioners receive knowledge | Number of practitioners   | Meeting/presentation participant tracking | 130 practitioners and resource professionals received knowledge                                                                                       |
|                            |                                                                                            | 1 additional BDA project in planning                  | Number of projects        | Project tracking                          | 1 additional BDA project in planning and 1 in implementation with 2 national forests.                                                                 |

## Monitoring Methods and Results

### *Carbon Dioxide Gas Flux*

Evan Wolf, PhD, conducted pre-project carbon dioxide (CO<sub>2</sub>) flux monitoring in spring/early summer 2021, 2022 and 2023 at 12 plots distributed across ~10 ha of Faith Valley. This monitoring was funded by the CDFW grant that ended in March 2024, so this monitoring was not continued in 2024. This monitoring measured the ecosystem uptake of CO<sub>2</sub> as photosynthesis and the release of CO<sub>2</sub> to the atmosphere as respiration using a closed-chamber system with an opaque cover connected to an infrared gas analyzer (IRGA). To determine the net ecosystem exchange of CO<sub>2</sub>, whether each plot is gaining or losing carbon over a growing season, he related the measured environmental variables to CO<sub>2</sub> flux using a model, and used that model to fill in the gaps between measurement periods (Wolf 2017, Chapter 3 pages 61-76). This allows for accurate estimates of whether each plot has gained or lost carbon via CO<sub>2</sub> during the growing season. The results of this monitoring are included in Appendix B: GHG Monitoring Report 2021-2023. Results show that the meadow stored Mg CO<sub>2</sub> in 2021 and lost Mg CO<sub>2</sub> in 2022 and 2023, with net overall loss of Mg CO<sub>2</sub> over the study duration. This is likely linked to the difference in the length of the growing season, with 2021 having about 40 additional days compared to 2022 and 2023. Based on expert consultation, since the project was only fully implemented in 2023, it would likely take several additional seasons for this monitoring to reflect the effects of restoration activities on increasing carbon storage.

### *California Rapid Assessment Method (CRAM)*

We conducted pre- and post-project assessments using the CRAM method for slope wetlands (which includes wet meadows) in the summers of 2019 and 2024 (when vegetation identification is easiest). We established a 0.9-ha Assessment Area (AA) that spans from the channel to the upland edge within the downstream portion of the project footprint (Appendix C). We selected this location because the project team originally planned to install the first phase of pilot BDAs in this reach, directly upstream of the grade control structure. However, we ultimately did not install features in this reach due to the presence of a large, persistent natural beaver dam just downstream, which was creating hydrologically connected conditions that would have needed to be removed to install features. This large beaver dam created ponded conditions in the AA reach from 2021-2023 until it blew out in winter 2023-2024, likely affecting the AA and leading to restoration effects that are less pronounced than they might have been under the original plan. The AA is located between the downstream grade control and the most downstream BDA series (12.1-12.3) which may have had some indirect effect on channel conditions on the AA (e.g. ponding and spreading of flows upstream and downstream).

Both assessments have been uploaded to the CRAM website and are available online through the EcoAtlas database (<https://www.ecoatlas.org/regions/ecoregion/statewide?cram=1>). The results of these assessments are summarized in Table 2 below. The complete Summary Assessment Reports are included as Appendix C: Pre-Project CRAM Summary Assessment Report and Appendix C.1: Post-Project CRAM Summary Assessment Report.

| Attribute                    | 2019  | 2024  |
|------------------------------|-------|-------|
| Buffer and Landscape Context | 80.79 | 80.79 |
| Hydrology                    | 70.83 | 66.67 |
| Physical Structure           | 50.00 | 62.50 |

|                            |           |           |
|----------------------------|-----------|-----------|
| Biotic Structure           | 68.75     | 70.83     |
| <b>Index Score (Total)</b> | <b>68</b> | <b>70</b> |

Table 2. CRAM Attribute and Index Scores. All scores are out of a possible 100. Scores in green improved from 2019, and scores in orange declined.

Scores for the Physical Structure and Biotic Structure attributes increased slightly following project implementation, which was in both cases due to the increase of a single metric in each category. Within the Physical Structure attribute, Structural Patch Richness increased, meaning that more distinct physical surface types that may provide habitat in the AA were observed following restoration. Within the Biotic Structure attribute, Plant Community Score also increased, meaning that a higher diversity of plants was observed following restoration.

The Hydrology attribute saw a reduced score following restoration, also due to the decrease of a single metric. The Percent Dewatered score decreased (meaning that the percentage of the AA that was dewatered increased), which was driven by the formation of rills and gullies on the wetland surface. This may have been due to a variety of downstream hydrological changes; for example, a persistent beaver dam blew out just downstream of the AA in 2023, which may have promoted temporary soil instability in the area (in turn leading to increased drying or gullying). Despite this, the composite Index Score increased, and the results of the CRAM monitoring demonstrate success across two of the four CRAM-measurable project objectives (Table 2).

### *Photo Points*

The project team established a set of photo points throughout the project provide visual documentation of existing conditions, immediate post-project conditions, and long-term conditions. We established photo point locations at recognizable features and established photo views based on bearings. We established 13 initial pre-project photos points in fall 2019 and an additional six points in spring 2020. We took photos twice each season, once in the spring/early summer and once in the fall 2020-2024. We established eight additional photo points in August-October 2022 and July-October 2023 to document specific project activity locations that had been determined based on field fit. Appendix D: Pre- and Post-Project Photo Point Monitoring Report shows the location of photo points and as-built project features and includes representative spring and fall pre-project photos from 2019 and 2020 and additional pre- and post-project photos from 2022-2024. Photo points serve to reinforce the results of the repeat topographic survey and TU's Stream Habitat Conditions Monitoring demonstrating improved floodplain connectivity. Numerous photo points, especially FV PP 4, FV PP 9 and FV PP 10 and 22-3, show sustained saturated conditions where the channel is well-connected to the floodplain, associated with project features following implementation. Pre- and post-photos show the reduction between bankfull channel elevation and historic floodplain associated with features, making overbank flooding more likely. FV PP 10 Bearing 273° shows that flows are spreading laterally across the floodplain, demonstrating increased frequency of overbank flooding. Photo points also indicate that road repairs are functioning to restore natural flow paths.

### *Topographic Survey*

Waterways Consulting conducted a detailed topographic survey of the Faith Valley stream channel and adjacent OHV road in fall 2018 as part of the baseline conditions assessment. This included a series of cross-sections and a longitudinal profile of the stream channel and meadow floodplain, with results provided in Appendix E: Waterways Pre-project Topographic Survey. In 2022, Waterways returned to document as-built conditions of the grade control structure. They surveyed the OHV road again in fall

2023 to support the development of the as-built drawings (Appendix A). In fall 2024, Waterways repeated the cross sections and the longitudinal profile surveys throughout the project reach where project activities occurred to develop stream-channel as-built drawings, which are included in Appendix A.1. This survey was conducted one year after full implementation and following adaptive management actions completed in 2024. While coarse bedload accumulation upstream of project features is anticipated, sediment movement is episodic, and it remains too early to observe substantial aggradation.

Sheet C1 of Appendix A.1 shows the locations of repeat cross sections throughout the ~5800-ft reach where restoration activities occurred, and the data from 2018 and 2024 are shown in Sheets C3-C4. Unintentionally, several cross sections are located just downstream of a series of BDA features, making them less likely to capture aggradation associated with the upstream features. The comparison of the 2018 and 2024 data mostly shows a lot of variability, with areas raised in 2024 offset by areas lowered. This could be due to coarse sediment bars shifting and new scour patterns. Section F shows substantial aggradation, while Sections A and E show slight aggradation. Section F is located at the upstream end of the reach that was flooded by a large natural dam that persisted 2021-2023 before being blown out in 2024. Sections A and E are upstream of the BDA series. This demonstrates an initial trend toward aggradation, but additional seasons would likely be needed to see more substantial aggradation.

Sheet C2 of Appendix A.1 shows the longitudinal profiles from 2018 and 2024, and the estimated low water elevation and the left and right bank elevations from 2018 (which should not have changed substantially). The purpose of the longitudinal profile performed in 2018 was to evaluate reach-scale slope and riffle grade elevations relative to the adjacent meadow surfaces, which did not require a high density of data points. Because of this discrepancy, the 2018 survey did not capture most of the pools that are detailed in the 2024 post-project survey, which included a higher density of data points. Therefore, a direct comparison of the longitudinal profiles to evaluate overall channel aggradation is a bit misleading (e.g. 2024 shows a greater number of deeper areas than in 2018 because some points were not surveyed in 2018). However, we can still evaluate the riffle grade elevations, which affect the estimated low water elevation. Throughout the reach where BDAs were installed through 2023 (~4,500 ft), the BDAs constituted a high density of higher elevation features in the 2024 survey compared to the 2018 surveys, essentially functioning as raised riffles. In turn, low flow water elevation was higher in 2024 than in 2018 by ~0.5-2 ft throughout this reach. At certain points where the banks are lower (~27+00 and ~54+00), the elevation of the BDAs and associated low flow water surface were very near to the bank elevation (within 1 ft), suggesting flows can likely access the floodplain at higher flows, improving floodplain connectivity. This pattern was not observed in the upstream and downstream reaches, except where the grade control structure (~6+00) created another raised riffle thereby increasing the low flow water elevation. In these reaches, beaver dams from 2018 performed similarly to the BDAs, creating raised riffles and augmenting the low flow water elevation.

### *GPS Measurements*

The project team used GPS measurements and GIS to document the restoration actions completed in 2022 and 2023, and adaptive management activities in 2024. During final project planning, designs were refined to omit work in the most upstream end of the project area, as this area was in good condition and the design team did not feel that disturbance associated with construction activities was warranted. Based on this omission, we estimate that the project directly affected ~100 acres. In total, 42 structures were installed. We GPS-located each BDA feature, noting the feature type where relevant (e.g. whether a structure was a starter dam or post line with wicker weave; whether a structure was installed with

equipment or with hand labor; and whether the weave was completed or not) (Appendix A, Appendix A.1), and tracked their performance (including damage and repairs) over the project period to inform adaptive management (Table 3). The exceptionally high-water year of 2022-2023 resulted in substantial damage to numerous pilot BDAs. Several structures had substantial scour pools and were rebuilt on the adjacent riffle rather than repaired. In 2024, only 2 structures had substantial damage and needed large repairs. The project team implemented small repairs and improvements to 29 preexisting structures to address end-running or reinforce the weave to enhance long-term durability. Based on a GIS analysis of Waterways' topographic survey of the OHV road, ~ 1940 linear feet (0.37 miles) of road repairs were constructed.

| Season | New Install       |              |                               |                          |           | Repairs            |                                       |                    |                              |                   |                         |
|--------|-------------------|--------------|-------------------------------|--------------------------|-----------|--------------------|---------------------------------------|--------------------|------------------------------|-------------------|-------------------------|
|        | Equipment Install | Hand Install | Equipment Install, Posts Only | Hand Install, Posts Only | Total New | Substantial Damage | Small Damage or Improvement Warranted | Hand Labor, Repair | Equipment, Posts Only Repair | Weave Only Repair | Total Repaired/Improved |
| 2022   | 7                 | 5            | 1                             | 1                        | 14        | 12                 |                                       |                    |                              |                   |                         |
| 2023   | 13                | 11           | 1                             |                          | 25        |                    |                                       | 2                  | 1                            | 1                 | 4                       |
| 2024   |                   | 2            |                               | 1                        | 3         | 2                  | 27                                    | 23                 |                              | 6                 | 29                      |

Table 3. BDA as-built quantities for the 2022-2024 seasons.

### *Beaver Dam Inventory*

The project team conducted monitoring to evaluate the location and persistence of beaver dams and lodges in the project area from 2016-2024, which involved collecting GPS locations, photos, measurements, and active status of all beaver dams and lodges throughout the project reach. Data was collected once in 2016 and 2017, then twice per year 2018-2024 (soon after snowmelt (pending access) and in the fall), to evaluate dam persistence during winter/spring high flows and dam construction during summer/fall low flows. This monitoring also informed the interpretation of groundwater and streamflow monitoring results, since beaver dams can raise local groundwater levels. Additionally, understanding annual presence of beaver dams can inform baseline streamflow conditions and the movement of water rights releases throughout the project area in comparison to post-project conditions.

In 2022, the methodology was modified to include observations of BDAs. We noted those without evidence of beaver activity, those with signs of beaver use (e.g., sedges added, chew sticks), partially constructed BDAs where posts were installed but willow weave was not completed, and damaged BDAs. The results of monitoring from 2016-2024 are presented in Appendix F: Beaver Monitoring Report 2016-2024. Appendix F.1: Beaver Monitoring and Groundwater Layered PDF shows beaver monitoring and groundwater locations, in which the layers sidebar can be used to turn seasonal beaver data layers on and off to interpret interannual groundwater data. Results from beaver monitoring indicate that the project has substantially increased the annual number of beaver structures post-restoration and the persistence of one feature maintaining grade: the grade control structure built in 2022 that replaced a series of large dams that had been periodically blown out. Beyond the grade control structure, monitoring results indicate a trend toward an increasing number and persistence of channel-spanning dams throughout the meadow. All BDAs installed during Phase 2 and included in the fall 2023 survey remained intact through winter 2023/2024. Overall, the number of channel-spanning structures providing grade control has increased substantially since implementation. While these results are promising, additional seasons of data would be necessary to evaluate the long-term persistence of

Phase 2 structures, especially under higher flow conditions. Additionally, the project may have contributed to the persistence of a large beaver dam upstream of the grade control structure (which had been effectively maintaining grade and creating persistent inundation) through the high flows of the 2022/2023 winter, but it was subsequently blown out in the 2023/2024 winter. Monitoring results further suggest an increase in both the extent and duration of ponded water associated with beaver and BDA features. Importantly, beaver appear to be actively colonizing BDA structures, a development which is likely to support the long-term maintenance of these structures and contribute to overall project success. For additional monitoring results and conclusions, see Appendix F.

### *Streamflow and Temperature*

The project team measured streamflow and temperature upstream and downstream of the project reach to assess project-related changes and determine whether project activities are affecting a water rights streamflow release, owned by the Carson Water Subconservancy District, that passes through the project area. In fall 2018, we installed logging pressure transducers to continuously measure stream stage and temperature above and below the project area. Loggers were added and replaced as necessary throughout the monitoring duration. Discharge measurements were collected monthly during spring/fall through October 2024. American Rivers and Trout Unlimited (TU) established this monitoring. American Rivers led data collection and TU led data analysis. The results of this monitoring are included in Appendix G: WY2019-WY2024 Streamflow Summary Report.

Monitoring results from water years (WYs) 2019-2024 indicate that in WY2023 and WY2024, following full implementation, released water flowed freely through the project site, similar to previous years. The volume of flow entering and exiting the project reach remained consistent across WYs, suggesting that release water was not lost to the system. Based on existing literature, the project team hypothesized that restoration would enhance downstream baseflow, resulting in greater outflow relative to inflow during summer/fall (June-November). To evaluate this, TU compared upstream and downstream flow volumes in September across all monitoring years. Observed trends from early to late September show a general pattern of downstream flow shifting from gains to losses, in both pre- and post- restoration years. However, a comparison of September flow volumes during years without substantial flow spikes revealed a shift: pre-project, upstream flows were higher than downstream flows; post-project, the opposite was true, indicating that restoration may have improved downstream baseflow. Still, variability between pre-project dry years and an average post-project year complicates direct comparison. TU also compared average flow volumes at the upstream and downstream sites for the full dry season (June-October) and for a narrower late season window (August-October). It is important to note that results from the dry season are less reliable due to less measurements collected during early season high flows. Across both timeframes, differences in flow volumes varied year to year and did not show a consistent trend between pre- and post-restoration. Daily average temperature data show slightly higher temperatures downstream than upstream, both before and after restoration, which is the opposite of what was anticipated. While the cause of this is unclear, temperatures upstream and downstream remained below thresholds of concern for native fish.

### *Groundwater Wells*

The project team measured groundwater levels at seven wells across three transects in the project area. The wells were installed in spring 2019 and were equipped with logging pressure transducers to collect continuous data. We collected manual measurements and downloaded logger data approximately monthly during spring-fall 2019-2023. Manual measurements were used to calibrate the logger data. American Rivers led groundwater monitoring, aided by Alpine Watershed Group. Groundwater data

show that BDA installation has significantly increased local water table elevations during summer/fall and that the project has raised the water table surface closer to the targeted depth of three feet below the meadow surface over baseline.

The results of this monitoring are included in Appendix H: Groundwater Monitoring Report 2019-2024. The results of the beaver monitoring (Appendix F and F.1) are helpful for interpreting the groundwater data and are incorporated into the groundwater analysis. Results from June-Nov 2019-2024 show significant increases in average groundwater levels at the middle transect (adjacent to project BDAs), but not the upper or lower transects. A significant increase was observed in the lower transect in 2023, but not in 2024, likely because a large beaver dam that had elevated the water table blew out in 2024, resulting in a substantial drop in groundwater levels. However, by fall 2024, groundwater levels had nearly rebounded likely due to the presence of a beaver dam on the downstream grade control and the BDA series just upstream. Results also indicate that, post-restoration, the average water table depth from June-November was less than three feet below the meadow surface at the downstream transect (following Phase 2 or restoration in 2023), and average water table depth was closer to the meadow surface at the middle and upper transects. It is important to note that post-project results are likely influenced by the historically high-water year of 2023. Still, groundwater monitoring results provide strong evidence that restoration has significantly increased groundwater storage in the project area as intended.

### *Institute for Bird Populations' Multi-Species Bird Monitoring and Willow Flycatcher (WIFL) Surveys*

American Rivers partnered with the Institute for Bird Populations (IBP) to conduct pre- and post-project multi-species bird monitoring and Willow Flycatcher (WIFL) surveys using two distinct bird survey and monitoring protocols. These protocols included *A Willow Flycatcher Survey Protocol for California* (Bombay et al. 2003) and *Avian monitoring protocol for Sierra Nevada meadows: a tool for assessing the effects of meadow restoration on birds* (Loffland et al. 2011a). The first is a targeted single-species survey protocol used to determine the presence/absence of WIFL and the approximate number and location of territories. The second protocol is used to describe the bird community and detect population-level changes in meadow-associated focal bird species in response to restoration activities. The second also includes assessment of habitat characteristics including vegetation, surface water, bare ground and other biotic/abiotic factors within 50m of all multi-species point count stations.

Faith Valley is a long-term monitoring site for IBP because it was a recent WIFL breeding site in the 1980s and early 2000s. IBP conducted multi-species bird monitoring and WIFL surveys in 2010, 2012, 2017, and 2018. The 2018 survey was funded by NFWF as pre-project monitoring. The results are included in the pre-project bird survey report (Appendix I). IBP conduct post-project surveys in 2024. Results are included in the post-project bird survey report (Appendix I.1). The multi-species monitoring showed that species with the least restrictive habitat needs were the most abundant, while species with more restrictive habitat needs, such as saturated conditions, were less abundant, likely because the associated conditions only occurred in smaller areas in Faith Valley.

To help interpret change over time, IBP reviewed historic satellite imagery since the 2010 surveys, which suggests that there was an expansion of beaver activity during drought years around 2016. They compared results from 2010 and 2012 surveys to the 2016 and 2017 (following beaver activity expansion) as well as post restoration in 2024. They saw mixed results in focal species response to restoration in 2023 and the expansion of beaver activity in 2016. Most species showed no response, but

Song Sparrow and Wilson's Warblers increased significantly in Faith Valley following expanded beaver activity and restoration, as compared to the control. Riparian shrub cover at survey plots showed no increase over time in response to beaver activity or restoration. This parameter will likely need more time to show change. Proportions in each of four willow age/height classes showed no distinct response to restoration, or pattern over time. Instead, IBP saw great variability in percent of age class at Faith Valley as compared to the control. This could be due to the manipulation of willow by beaver as they move in Faith Valley. They anticipate increased willow coverage and increased willow heights at Faith Valley as human restoration efforts in 2022-2024 help beaver to maintain primary channel dams from season to season. For WIFL surveys, no WIFL were detected in 2010, 2012 or 2016. A single male was detected in 2017 but not nesting activity. In 2024, a single male was detected as well as a nest. While follow-up observations suggest nesting was not successful, this represents the first observed nesting activity in Faith Valley since 2002. Confirmation of nesting is a very meaningful event for a population that has been significantly declining in the Sierra Nevada for the last 2 decades. Recolonization of Faith Valley during the first post-restoration year is a strong indicator of success.

### *Trout Unlimited's Stream Habitat Conditions Monitoring*

American Rivers partnered with TU to conduct pre-and post-project monitoring of stream habitat conditions in the project area using a modified version of the USDA Forest Service Stream Inventory Protocol (USFS 2010). This protocol involves gathering quantitative habitat data on stream channel geomorphology and condition, instream habitat types and diversity, riparian vegetation cover, vegetation community structure and condition, floodplain connectivity, substrate, and large woody debris. The protocol centers on the instream channel unit as the basis of assessment and breaks the survey area into larger hydrogeomorphic reaches with distinct characteristics for results reporting. With funding from NFWF, TU conducted pre-project monitoring in fall 2016 and post-project monitoring in fall 2024. Pre-project results are included in Appendix J: Pre-Project Stream Condition Inventory. Post-project results are included in TU's Post-Restoration Stream Condition Inventory 2024 (Appendix J.1). The Faith Valley survey area included four hydrogeomorphic reaches numbered from downstream to upstream (GM1-GM4). GM1 includes the grade control and area just upstream with minimal BDAs, GM2 includes substantial BDAs, GM3 includes BDAs in the lower half, and GM4 received no treatments and is a control that includes natural beaver activity.

TU's monitoring is useful to evaluate a suite of project objectives and performance measures. Importantly, results from TU's monitoring indicate that the elevation of the historic floodplain above bankfull indicator (channel entrenchment) was reduced in each of the 3 reaches (totaling 7023.2 ft) where implementation activities occurred (GM1-3), while the opposite occurred in GM4 where no treatment was undertaken. This mostly clearly demonstrates the benefits of the project toward the overall design goal of reducing or reversing channel incision. Monitoring results also indicate a substantial increase in flood-prone width within reaches GM2 and GM3 (totaling 5,077.7 ft of channel) following project implementation. This change reflects a rise in water surface elevations and a reduced elevation gap between the current bankfull stage and the historical floodplain, resulting in more frequent overbank inundation at lower flows and improved floodplain connectivity. Flood prone width remained about the same in GM1, as this area was well connected in 2016 due to a substantial beaver dam at the location of the current grade control.

The monitoring results also demonstrate that the BDAs increased bank stability. In the two reaches with substantial BDA structures installed, GM2 and GM 3, project activities reduced the extent of unstable banks by 921.9 ft across a combined reach length of 5077.7 ft. The extent of unstable banks increased

by 75.13 ft in the downstream reach (GM1, 1945.5 ft) upstream of the grade control, largely due to the loss of a large beaver dam in 2016.

In addition to increases in flood prone width, the average wetted width also increased across the three reaches where implementation occurred (totaling 7023.2 ft of channel), indicating a trend toward greater spatial extent of seasonally inundated habitat in the treated reaches. Significant habitat changes were observed by reach. In GM2, where most of BDAs were constructed, the reach transitioned entirely to slow water units (e.g. pools); however, TU noted that BDAs also create short cascade features that introduce fast water and promote reoxygenation. GM1 shifted to increased fast water units, while GM3 had a moderate shift toward more slow water units. Although overall heterogeneity has decreased in the short-term, it is expected to increase over time as floodplain connectivity facilitates the formation of new side channels and flow paths. Average bankfull width increased at the 3 implementation reaches and decreased in the untreated upstream reach, likely due to lateral expansion of ponded water behind BDAs. The average bankfull depth increased in the 2 downstream reaches, especially in GM2 where most BDAs were installed, and decreased slightly in the 2 upstream reaches.

Understory vegetation cover of grasses and forbs (mesic vegetation indicators) showed minimal change, while sedge and rush (wet vegetation indicators) cover increased in all reaches, which may be due to seasonal climatic conditions. Overstory cover of willows and conifers remained largely unchanged. Additional monitoring seasons are likely needed to detect more definitive vegetation responses to restoration. See TU report for more details.

### *Vegetation Mapping*

Overlin Botanical Consulting (Overlin) conducted vegetation mapping during the baseline condition assessment for Faith Valley in 2018. They mapped vegetation assemblages based on 1) dominant vegetation type as it relates to meadow wetness (e.g. *Carex* species or facultative wet species dominated) and 2) the functional status of the vegetation (e.g. functional vs at-risk vs potential for re-watering). See Appendix K for map and vegetation classification categories. Unfortunately, Overlin's vegetation mapping could not be completed post-project as the consultant no longer works as a botanist and left the state. However, Trout Unlimited's stream habitat conditions monitoring includes vegetation parameters and they also used remote sensing tools to evaluate changes in Normalized Difference Vegetation Index (NDVI) throughout the meadow to evaluate vegetation changes post-restoration (Appendix J.1).

### *Outreach and Project Tracking*

American Rivers tracked outreach to meadow restoration practitioners and resource professionals over the duration of the implementation grant period (2020-2024) and determined that 130 individuals received project-related knowledge. Outreach included periodic updates to the Faith Valley Meadow Restoration stakeholder group and the Sierra Meadows Partnership, and site visits and formal presentations, including at the 2022 Carson River Watershed Forum.

Faith Valley is serving as a model for expanding implementation of projects using BDAs. Since its completion, American Rivers implemented another project incorporating BDA/PALS with the Humboldt-Toiyabe at Grouse Meadow and is currently planning a BDA project with Eldorado National Forest at Forni Meadow.

## Monitoring for Performance and Adaptive Management

As the project implementation period and funding have ended, the project team will transition to adaptive management monitoring in accordance with the Long-Term Maintenance and Management Plan. American Rivers will continue a subset of monitoring activities for at least two years following 2024 to assess project outcomes and determine the need for further adaptive management. Each spring, the project team will monitor photo points and visually assess site performance during high flows. An abbreviated version of the beaver monitoring will also be conducted to evaluate whether beavers are maintaining projects features. If monitoring indicates that beaver activity is insufficient to maintain structures and meet long-term objectives, particularly reestablishing connectivity between the channel and meadow floodplain, the project team will pursue additional adaptive management actions.

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