Section 5: Project Description

1. **Project Objectives:**

The primary objective of the Mountain Meadows Restoration Project at Greenville Creek and Upper Goodrich is to restore ecologic function to 253 acres of degraded dry mountain meadow habitat. Project outcomes are expected to include: increased soil carbon sequestration; increased groundwater elevations and floodplain aquifer function; increased vegetative productivity and community balance toward wet meadow species; and improved habitat for migrating birds and waterfowl. Based on similar previous projects, quantified expected outcomes for greenhouse gas reduction of carbon dioxide include a 50% increase in sequestered soil carbon within two years. Net GHG fluxes may either contribute to, or reduce, the carbon sink strength of restored meadows, depending on methane and nitrous oxide production or consumption. In fact, Blankinship and Hart (2014) found these gases were most sensitive to the changes in surface hydrology that would be expected with meadow restoration. The potency of methane and nitrous oxide as GHGs relative to carbon dioxide necessitates that these gases be included in the overall GHG budget of a purported GHG reduction project.

The overall objective of the research component of the project is to quantitatively investigate the net greenhouse gas emissions and sequestration associated with mountain meadow. The hypothesis is that re-establishing the hydrologic channel/floodplain connectivity of mountain meadows will increase net carbon sequestration. The research proposes to use sampling, lab, and analysis procedures developed with the Sierra Meadow Restoration Research Partnership (SMRRP), to allow data analysis over a broad range of meadow types.

Based on similar previous projects, quantified expected co-benefit outcomes include: 1) a three-foot elevation increase in spring and early summer groundwater elevations within one year; 2) a 102 acre-feet increase in shallow floodplain aquifer volume (a 3’ increase in shallow floodplain aquifer depth, divided by two for the conservatively expected cone shape of affected groundwater, multiplied by 253 acres, and by 0.27 for porosity (Cornwell and Brown 2008)); 3) a 100% increase in vegetative meadow productivity within two years; 4) a 100% increase in the ratio of wet meadow plant species to dry meadow grass/forb species within two years; 5) increased flow duration into the summer; 6) enhancement of 253 acres of mountain meadow floodplain with 12.1 acres of surface water in ponds, and improved riparian habitat vegetative vigor for waterfowl and sandhill cranes.

Mountain meadows are among the most important habitats for birds in California (Burnett et al. 2005); they support several rare and declining species in the Sierra Nevada and are utilized at some point during the year by almost every bird species that breeds in or migrates through the region. Meadows also perform a vital role as watershed wetlands that store and purify drinking water for millions of Californians.

Restoration of this landscape works toward achieving the habitat objectives for the Southern Oregon Northeastern California (SONEC) region, an important area for breeding and migrating Pacific Flyway waterfowl as outlined in the IWJV 2013 Implementation Plan; as well as objectives outlined in the Mountain Meadows Watershed Restoration Action Plan and the Upper Feather River Watershed Integrated Regional Water Management Plan.

2. ***Background and Conceptual Models:***

Similar to many montane meadow floodplains throughout the Sierra Nevada and Cascade mountain ranges, the Greenville Creek and Upper Goodrich meadow floodplains no longer flood on a seasonal basis, and are in poor condition, with little to no wildlife habitat value. Downcut stream channels profoundly alter floodplain meadow hydrology and ecosystem functions such as shallow aquifer retention and release, vegetative productivity, and wildlife habitat value. Project implementation would restore the basic hydrologic function of 253 acres of degraded montane meadow by eliminating downcut stream channels and allowing floodplain drainage to occur at floodplain elevation. The project would be accomplished using the “pond and plug” technique. This technique has been used to successfully restore over 8,000 acres of channel/floodplain function throughout the Sierra Nevada, and beyond, since 1995.

While a few projects have required maintenance or repair, the pond and plug technique generally has a proven track record of success. The Big Flat pond and plug project area performed well with little damage in the 1997 100+ year return-interval flood, two years after construction. The Big Meadows pond and plug project also performed well with no damage in another 100+ year event in 2009. Pond and plug restores the characteristically resilient processes within intact channel/floodplain systems, and is a well-suited technique for the wide, flat floodplains in the Mountain Meadows projects. Climate change predictions include an increase in the extremes of precipitation (frequency, intensity and drought). Functional mountain meadow floodplains can incrementally attenuate flood flows, and release shallow floodplain aquifer moisture during periods of drought.

In both meadows, stream flows are confined to 3-foot+ channel incisions, with eroding banks, and little to no riparian habitat. The Greenville Creek area encompasses approximately 181 acres and two stream channels: Greenville Creek, and an unnamed channel here referred to as “Stroing Creek”. Greenville Creek, on the west, has a watershed area of 3.5 mi^2; and Stroing Creek, on the east, has a watershed area of 4.9 mi^2. Both creeks flow northwest into Mountain Meadows Reservoir and, ultimately to the North Fork Feather River. The valley gradient within the project area transitions from 1% at the upstream end to less than 0.1% at the downstream end. There are well defined remnant channels on the surface of the expansive floodplain meadow that are no longer primary flow paths since the development of channel incision. Channel incision appears to be primarily due to the synergistic effects of the historic railroad grade and subsequent road culverts across the top of the project area, combined with significant channel manipulation for irrigation and over 100 years of intensive grazing. The following photos document existing conditions.

Figure 1. Looking down valley at the incised “Stroing Creek” channel from the road, within the Greenville Creek project area, showing the expansive floodplain and damaged road culverts.

The Upper Goodrich project area is located in two headwater meadows that form an unnamed tributary to Goodrich Creek. The project encompasses 72 acres of meadow floodplain. The two meadows, east and west, drain watershed areas of 1.5 mi^2 and 4.5 mi^2, respectively, each with slopes of approximately 1%, with a 3% slope in the neck below the west meadow. Multiple headcuts are actively migrating up both meadows, converting functional sheetflow and shallow channel floodplain drainage to single-channel drainage that ranges from 2.5 to 4.5 feet deep. The upper extent of the project work is at the top of the headcuts, and continues down through the incised reach, terminating 1,900 feet below the confluence of the two meadows. Just below the project area, the channel is stable and not incised.

The principal mechanism for channel incision at upper Goodrich appears to be historic railroad logging grades constructed up both meadows and across the bottom of the east meadow, combined with long term intensive grazing. Prior to degradation, both meadows had a combination of sheet flow (i.e. no channel) and defined shallow remnant channels on the surface of the meadow. (Channels generally only develop where the accretion of streamflow and sediment supply is sufficient.)

Figure 2. Upper Goodrich Cr at cross-section 3 in June 2014, showing healthy vegetation within the incision, poor vegetation on the terraced meadow floodplain, and conifer encroachment.

Figure 3. Upper Goodrich at the confluence of the two meadows. June 2014. The railroad grade is visible on the left side of the gully in the background.

The likelihood of successful project implementation, with expected GHG reductions and co-benefits is high, based on the implementation of similar projects by Plumas Corporation since 1995. Following are monitoring data collected from various meadow re-watering projects since 1995. Similar results are expected in the proposed treatment meadows.

Figure 4 displays soil carbon differences in three restored versus unrestored meadows (FR-CRM 2010), showing twice as much carbon in the restored areas. While not shown in Figure 4, soil nitrogen stores were also twice as large in the restored versus the unrestored meadows. Existing conditions in the treatment areas indicate that carbon and nitrogen stocks will change similarly to the FR-CRM 2010 study in response to restoration. Norton et al (2011) also found twice as much carbon and nitrogen in moist, functioning meadows than in non-functioning meadows.

Figure 5 compares groundwater elevations in pre-project, versus post-project conditions, averaged over a number of years at Clarks Creek. A total of seven groundwater wells were installed in the Mountain Meadows treatment areas in late June 2014, showing an average depth-to-groundwater of 6.4' at upper Goodrich, and 6.6' at Greenville Creek, throughout the summer 2014 months. Similar benefits in groundwater elevation, and seasonal groundwater retention and release, are expected at the proposed treatment areas.

Figures 6 and 7 display an increase in vegetative productivity and shift to more wet meadow species from a pond and plug project in Red Clover valley, and a riffle augmentation project on Little Last Chance Creek, respectively.

Freeman (2010) stated that climate change is already affecting the timing and quantity of run-off in the North Fork Feather River watershed, due to a decreased snow pack in the Sierra Nevada. The project would incrementally address summer flows by retaining water later into the season in shallow mountain meadow floodplain aquifers, thus contributing to climate change adaptation from the loss of water retention as snowpack. Figure 8 displays seasonal flow extension at the Big Flat meadow on Cottonwood Creek in 2006. Pond and plug effects on stream flow can vary widely, and can depend on variables such as valley slope, climate, vegetation, underlying bedrock, watershed condition, etc. However, some stream flow extension is expected at both meadows.

Data collected by the California Department of Water Resources at the Red Clover McReynolds Project show an increase in waterfowl production. Pre-project surveys found 74 young waterfowl produced. Post-project surveys found 122 young produced (Feather River Coordinated Resource Management 2010). NRCS surveyed one bird point count location within the project area in 2014. They plan to survey again (pre-project) in 2015 with additional points. No waterfowl were detected in 2014.

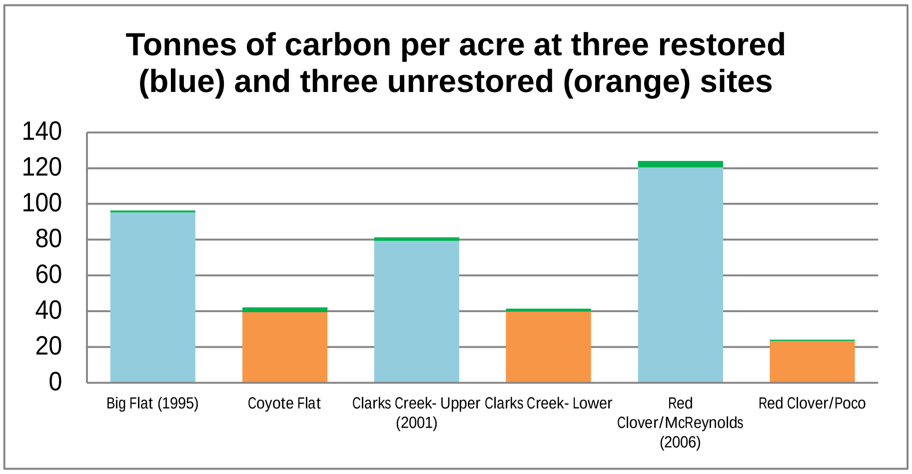

Figure 4. A comparison of soil carbon found in restored versus unrestored meadows. Post-project samples were collected on the Red Clover Poco project in 2014, with analysis planned for early 2015.

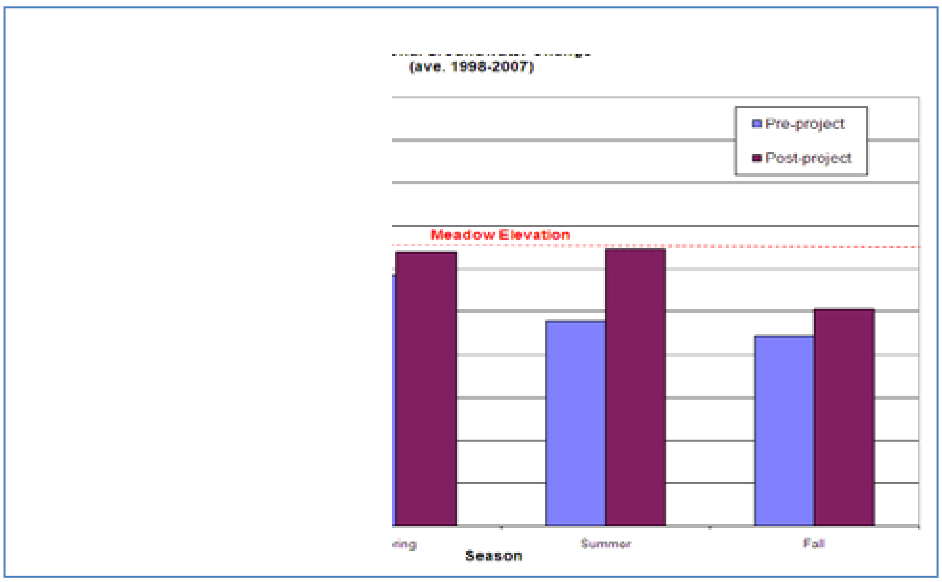

Figure 5. Seasonal average groundwater elevation changes from a pond and plug project on Clarks Creek in the upper Feather River watershed (unpublished monitoring data).

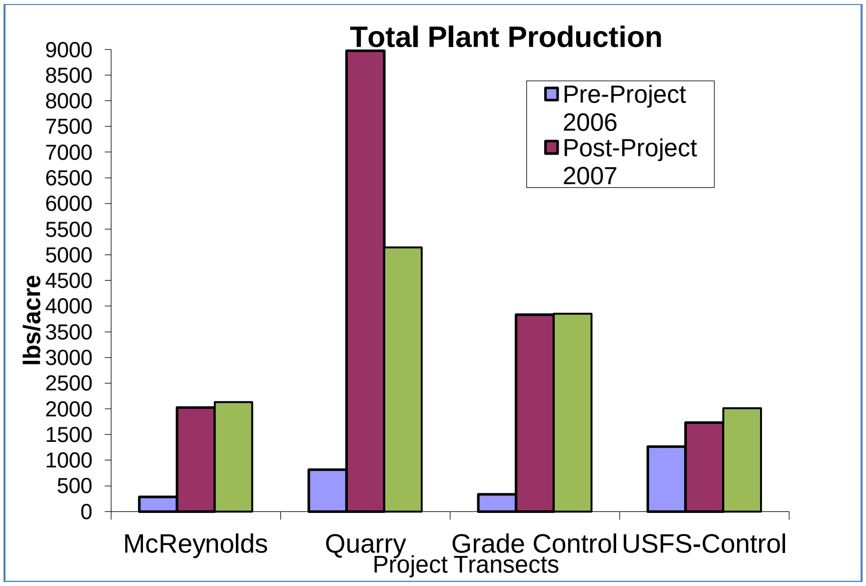

Figure 6. Vegetative productivity in years one and two after meadow restoration in the Red Clover McReynolds pond and plug project area (FRCRM 2010).

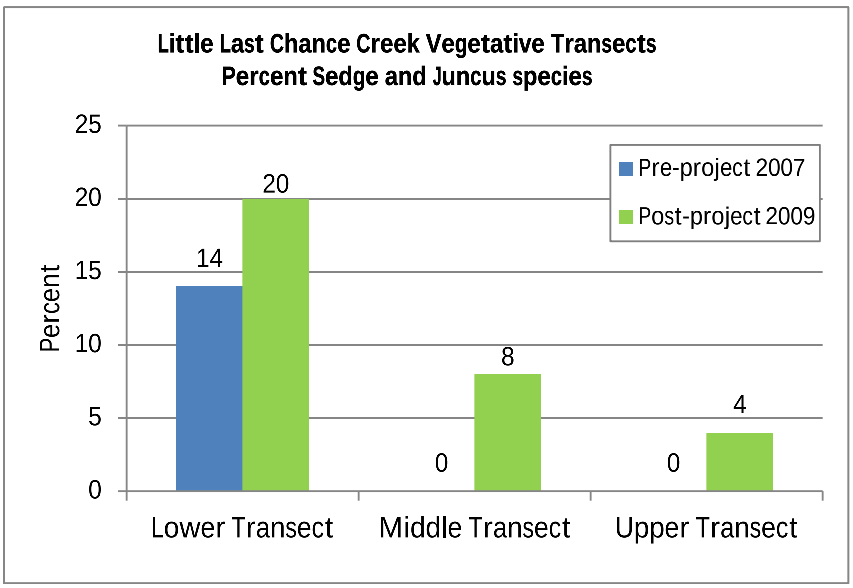

Figure 7. Comparison of plant community composition before and after a meadow re-watering riffle augmentation project on Little Last Chance Creek (FRCRM 2010).

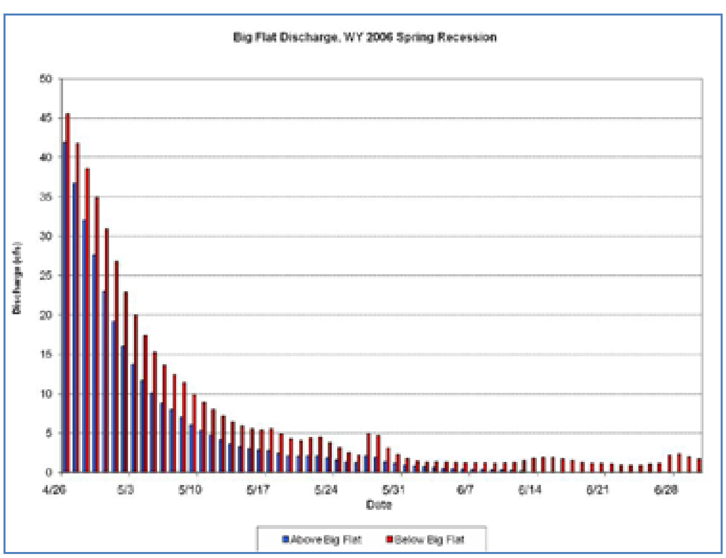

Figure 8. Seasonal flow extension of Cottonwood Creek in Big Flat meadow above and below a pond and plug project (unpublished data available at feather-river-crm.org).

3. ***Detailed project description, including all tasks to be performed:***

Tasks common to both treatment areas:

The pond and plug technique entails the use of heavy equipment to eliminate the incised channel as a drain on the shallow meadow aquifer. Parts of the gully are dug wider and deeper (resulting in ponded water) to obtain the material to build gully plugs up to the meadow surface, resulting in the replacement of the continuous gullied channel with a series of ponded water habitats and plugs. The elimination of the gully improves precipitation infiltration into the shallow floodplain aquifer, and allows slower seasonal aquifer drainage. To ensure rapid plug revegetation, top soil and meadow sod would be removed, stockpiled, and placed over the finished plug grade. Existing mature meadow sod would be transplanted from the gully bottom prior to excavation or filling. Transplants would be used to line the lower margins of the plugs for overland flow protection. Native seed would either be hand harvested from nearby ungrazed meadows, or purchased, and spread by hand on finished plugs. The project area would also be rested from grazing for two to three years following construction.

All construction work would be implemented by a construction contractor, chosen through a competitive bid process. Equipment to be contracted includes an excavator, wheel loader, track loader, and water truck. Construction would occur under the supervision of Jim Wilcox, of Plumas Corporation, and is expected to last a total of 36 working days for both meadows, occurring in late summer or early fall.

Pre-project co-benefit monitoring field data would be collected by Gia Martynn and Leslie Mink of Plumas Corporation in early 2015. Some parameters are already being collected. Post-project field data would be collected for two years following construction. All monitoring data would be recorded in a spreadsheet, summarized, analyzed and shared with the Sierra Meadow Restoration Research Partnership on an annual basis. Monitoring data and analysis would be documented in a project final report, and made available to the public on the Plumas Corporation website. GHG research, conducted by the University of Nevada Reno (UNR) protocols, data and results would also be shared with all project partners on an annual basis, and made available to the public after publication of peer-reviewed manuscripts.

Greenville Creek: The Greenville Creek treatment would entail the excavation of 24,500 yds^3 to eliminate the multiple gullies as conduits for flow. This material would be excavated from 15 borrow areas (ponds) with the resultant material used to construct 17 plugs. The total pond water surface area created would be 7.8 acres. Total plug surface area would be 4.5 acres. The remnant channel(s) are 7,350 feet long with an average floodplain width greater than 1,000 feet.

In addition to the gully treatment, the following two project design features would ensure a seamless transition for flows into, and out of, the Greenville Creek treatment area: 1) Replace the existing three 36" damaged (and unsafe) culverts on Stroing Creek where it crosses under the road at the upstream (south) end of the project. The culverts would be replaced with the same number and diameter, set at an elevation consistent with the restored base level of the proposed project. The existing rock-surfaced, flood-relief dip across the road would remain. 2) Treat nine small (1- 2 foot high) headcuts that occur at the interface of streamflow with Mountain Meadows Reservoir, each with 20 cubic yards of 1 foot minus rock (totaling 180 cu. yds.), to provide a sloping, armored pathway for these flows to enter the reservoir without further cutting into the meadow. (The headcuts have developed where overland flow from the meadow is concentrated in small swales not associated with the active stream channels. They activate when overland flow occurs, and the Mountain Meadows Reservoir is not yet full.)

Upper Goodrich Creek: The Upper Goodrich treatment would entail the excavation of 30,500 yds^3 to eliminate the gully as a conduit for flow. This material would be excavated from 17 borrow areas (ponds) with the resultant material used to construct 23 plugs. The total pond water surface area created will be 4.3 acres. Total plug surface area will be 6.5 acres. The remnant channels total 6,100 feet in length with an average floodplain width of 200 feet.

GHG Research:

This project will be included in the larger partnership research effort of the Sierra Meadow Restoration Research Partnership (SMRRP), using GHG research protocols for the "focus" meadows (i.e. more intensive data collection). Five meadows have been identified for GHG and soil carbon sampling, described further under the protocol section of this document. The two treatment meadows, Greenville and upper Goodrich Creek, would be sampled in the unrestored condition in 2015, and in the restored condition in 2016 and 2017. Two additional meadows that have been previously restored, Red Clover McReynolds (2006), and upper Clarks Creek (2001), would each be concurrently sampled to determine longer term potential for GHG reduction. An unrestored meadow, lower Clarks Creek, would also be sampled as a control. The treatment and restored meadows are paired, based on flow regime, parent material, and elevation. The Red Clover/ Greenville pair are perennial, and the Goodrich/ upper Clarks pair are intermittent.

For GHG sampling, static chamber collars would be installed in the soil at each site, within the major hydrologic zones (dry, moist, and inundated) identified along five surveyed topographic cross-sections (i.e. 10-15 chambers per meadow) in June 2015, with soil GHG flux sampling to begin one month after installation, using the static chambers described by Hutchinson and Mosier (1981), (also Blankinship and Hart (2014)). Samples would be collected every two weeks during the growing season, and monthly in the non-growing season, along with soil pore water and soil temperature. During snow-covered months, sites would be sampled two to three times to establish low rates of subnivean soil GHG flux. Samples would be analyzed at the UNR Soil Science and Ecosystem Ecology laboratory using a gas chromatograph.

In addition to the field sampling, soil and vegetation from the field would be transported to the lab and incubated within temperature- and humidity-controlled growth chambers, where future climate conditions can be mimicked to explore temperature effects on GHG fluxes and relationships between predictive variables. This work would take place in 2016.

Four soil carbon samples would be collected and analyzed for each of the five meadows in 2015, following the protocol described in FRCRM 2010. Post-project soil carbon would again be sampled and analyzed in Greenville and upper Goodrich meadows in 2017.

Co-benefit monitoring:

- Groundwater elevation monitoring has begun with the installation of six groundwater wells. Groundwater levels within the wells will be measured monthly when the project area is accessible, from June 2014, through three years after restoration construction.
- A total of three vegetative transects would be monitored at each meadow. The transects would be located along existing topographic cross-sections, and would follow the USDA protocol for total plant production described in chapter nine of the Monitoring Manual for Grassland, Shrubland and Savanna Ecosystems (Herrick et al 2005).

Species would be grouped into wetland status following the Army Corps of Engineers State of California 2014 Wetland Plant List (Lichvar et al 2014), with the percentage of wetland plants compared before and after treatment. Transects would be monitored in early summer on an annual basis, and would be compatible with vegetation data collected by other SMRRP meadows.

- Flow duration would be measured at the bottom of each project area with a HOBO data logger placed in the channel within a stilling well. Dataloggers would be installed as early as the project area is accessible in 2015, and downloaded monthly through the summer months on an annual basis until the channel is dry.
- Wildlife habitat value would be measured with bird point counts. One point count was conducted within the project area in 2014. Three to four additional point counts would be surveyed in spring and early summer 2015 under pre-project conditions and annually thereafter.
- GPS'ed photo points would also document overall changes in the vegetation and landscape. Photos would be taken annually in mid-summer.

Data analysis and reporting:

GHG emissions will be summarized annually and reported to the SRRMP team, along with biomass, groundwater levels, soil carbon and water content, and soil temperatures pertinent to each GHG sampling date. Project personnel will coordinate with the SRRMP team to review summarized data from all participating projects. It is anticipated that one or several peer reviewed publications on mechanisms that control GHG emissions and carbon sequestration in meadows will be produced through this task. Monitoring reports and published research will also be made available to the public on the Plumas Corporation website.

4. *Timeline:*

Activity	Timeline	Completion Date
Coordinate with project partners (including landowner)	On-going since 2010	on-going
Complete topographic surveys	Summer 2012	Aug 2012 (non-match*)
Preliminary project design	Summer 2012	Oct 2012 (non-match)
Finalize project design and layout	Summer 2014	August 2014 (non-match)
Botany, wildlife, and archeology surveys & reports	Spring/summer 2014	December 2014 (non-match)
Develop project monitoring plan	Summer/fall 2014	December 2014 (non-match)
Collect pre-project monitoring and research data	Summer/fall 2014 (wells); Summer 2015 (wells, flow, photos, veg, wildlife, GHG)	November 2015 (non-match, match & grant)
Complete CEQA/NEPA documentation	Winter 2014/15	February 2015 (non-match)
Signed CEQA Declaration	Spring 2015	April 2015 (non-match)
Complete permit applications	Winter 2014/15	February 2015 (non-match)
Receive permits	Summer 2015	June/July 2015 (non-match)
Develop land management & long term monitoring plan	Spring/summer 2015	July 2015 (grant & match)
Construct project	Summer 2015	Sept 2015 (grant & match)
Collect post-project monitoring	Fall 2015 through Fall 2017	November 2017 (grant &

and research data		match)
Final report & invoice	Winter/Spring 2018	June 2018 (grant)
Continued long term visual project monitoring	2018-2025	November 2025

*Non-match has been, or will be, completed by Plumas Corporation under a grant contract with the National Fish and Wildlife Foundation.

5. ***Deliverables:***

Deliverable	Timeline	Completion Date
Quarterly reports and invoices	September 30, 2015, and 30 days after every calendar quarter through June 2019	on-going
Land access permission letter	June 2015	June 2015
Land management plan	Spring/summer 2015	July 2015 (grant & match)
Project construction photos	Summer 2015	Aug 2015 (grant & match)
Final project and monitoring report, including all numeric & spatial data & final invoice	Winter/Spring 2018	June 2018 (grant)
Final invoice		June 2018

6. ***Expected quantitative results (project summary):***

The project is expected to reduce carbon dioxide (CO_2) by 23,189 metric tons (tonnes). Expected project effects on nitrous oxide (N2O) and methane (CH_4) are not sufficiently well understood to be quantifiable. The research component of the project is expected to provide quantitative figures on the effects of meadow restoration on these two GHGs, as well as soil CO_2 gas emissions. Inclusion of two older restored meadows will help determine the longevity of emission reductions in restored mountain meadows. The sequestration of carbon in the soil is expected to last in perpetuity, as long as the hydrology of the meadow remains in the restored state.

The expected reduction in CO_2 is based on a conservative estimate of a 50% increase in soil carbon. Restored versus unrestored meadow soil carbon comparisons (FRCRM 2010) have shown a 100% increase in soil carbon at the restored sites, however, known existing vegetative and hydrologic conditions in the Mountain Meadows treatment sites versus the sites used in the FRCRM 2010 study, warrant a 50% reduction in the expected outcome. Based on the 2010 study, existing carbon stores are estimated at approximately 50 tonnes of carbon per acre at the two treatment areas. 253 acres x 50 tonnes is 12,650 existing tonnes of carbon at the two sites. The project is expected to increase carbon by 50%, or 6,325 tonnes of carbon. To convert this sequestered carbon to carbon dioxide, the ratio of the molecular weights of carbon to carbon dioxide (3.6663) is multiplied. Thus, an estimated 23,189 additional tonnes of carbon dioxide would be sequestered in the meadow, minus estimated emissions during design, construction, and monitoring of 51 tonnes, leaving a net 23,138 tonnes or sequestered CO_2.

7. ***Protocols:***

- Soil carbon – Soil carbon will be sampled and analyzed following a protocol developed by the FRCRM in 2010. Each meadow is surveyed to delineate Level 1 soil types and existing vegetation communities. Four one-foot square plots are chosen along veg/soil representative topographic cross-sections, each plot representing a soil/vegetation type. Within these parameters, sample plot locations are randomly selected by tossing the square behind the back. (Note: The best representation of all vegetation/soil types is sampled in each meadow; however, not all types may be sampled and some may be sampled more than once. In an effort to make between-meadow comparisons, attempts to duplicate soil/vegetation types among similar meadows will be made.) Samples are removed within the one-foot square plot in the following layers: 1. All above-surface biomass material within the square is clipped to ground level. Soil surface is defined as the top of the O horizon. Material is removed, bagged and labeled by plot number for the entire square foot area. Documentation of meadow use and percentage of utilization is estimated. 2. In wet sites, a 4" auger-size sample of the O horizon is taken. In dry sites, the O horizon of the entire square foot is taken. O horizon material consists of duff, litter and residual live plant material, down to a bare, mineral soil surface. Material is removed, bagged and labeled, including a notation of whether the wet or dry site method is used. 3. In the center of the square, an auger is used to sample the top three feet of soil. A representative sample of each foot of depth is collected. Approximately 20% of the soil in the auger is removed for analysis, with an attempt made to collect material from the upper, middle and lower portion of the core. 4. During augering, a representative bulk density sample is collected for each foot of depth. Bulk density samples are collected at 9", 18" and 27". Soil cores are collected using an Oakfield 3-ft. Model B 36" Soil Sampler (mud augers worked best in wet sites). Bulk density samples are collected with a 0200 soil core sampler manufactured by Soilmoisture Equipment Corp. All samples are stored in plastic bags, and labeled with meadow, plot number, depth, and date.

Sample testing, including biomass, is conducted by the Soil, Water and Forage Analytical Lab at Oklahoma State University. All biomass material recovered from the one foot square is dried in a hot-air oven at a constant 105^{o}F. Dry weights are determined from a digital scale to a resolution of one gram. Dry weights are multiplied by 0.48 to determine total carbon of the sample (carbon makes up approximately 48%-50% of the dry weight of organic matter). Soil samples are also dried as above and sieved using an ASTM#10 (2mm) 8" brass sieve. Large organic material (roots) are removed and tested as above (small organic particles go through the sieve and become part of the soil sample). Approximately one teaspoon of each sieved soil sample is sent to the lab for testing with a LECO TruSpec Carbon and Nitrogen Analyzer.

- GHG – This project will collect GHG emissions according to the "focus meadow" methodology used by other projects involved in the SMRRP, with data collected at high spatial and temporal resolution. Five meadows have been identified for GHG and soil carbon sampling, described in the project description.

  The three meadows to be sampled in addition to the two treatment meadows will allow a robust analysis of data, over time and space. Pre- and post-treatment sampling in upper Goodrich and Greenville meadows will provide a same-site time comparison. The two paired restored meadows will not only allow a spatial substitution for time comparison with the treatment meadows, but will also enable analysis of sequestered carbon stocks over time, under typical montane meadow management (i.e. grazing). Both Red Clover and upper Clarks were sampled for carbon in 2008 in a restored condition (FRCRM 2010). Lower Clarks will act as a control for the treatment meadows, and also a control for the older restored meadows. Lower Clarks was also sampled in the FRCRM 2010 study.

For GHG sampling, static chambers would be installed at each site, within the major hydrologic zones (dry, moist, and inundated) identified along five surveyed topographic valley-wide cross-sections (i.e. 10-15 chambers per meadow) in June 2015, with soil GHG flux sampling to begin one month after installation, using the protocol described by Hutchinson and Mosier (1981), (also Blankinship and Hart (2014)), and other Sierra Meadow Restoration Research partners. Chambers will be constructed of polyvinyl chloride (PVC) tubing, approximately 30 cm in diameter (to reduce the inherent spatial variability associated with soil gas fluxes and optimize for continued ecosystem functions at a scale appropriate for understanding driving variables (Sullivan et al., 2010)). In the field, the vented static chambers will rest on bevel-edged PVC collars that are permanently installed 2-3 cm deep in the soil. Samples will be collected every two weeks during the growing season, and monthly in the non-growing season, along with soil pore water and soil temperature. Samples will be analyzed at the UNR Soil Science and Ecosystem Ecology laboratory using a gas chromatograph.

In addition to the field sampling, intact soil cores, including live vegetation, would be transported from both restored and unrestored sites to the lab, where they would be subjected to temperature manipulations to determine the response of GHG fluxes to potential climate conditions. In growth chambers, we will expose the cores to warmer temperature conditions predicted for the northern Sierra in 2050 based on Coupled-Model Intercomparison Project (CMIP)5 model estimates. The cores would be incubated at field moisture contents. Each week, the C content and GHG fluxes would be measured for soil cores incubated at elevated temperatures, and for cores incubated at ambient temperatures. This approach would allow some prediction of long term carbon sequestration and GHG fluxes of restored meadows that may be expected due to climate change.

- Groundwater elevation – monthly measurements (when the project area is accessible), with a hand held water level reader, in already-installed ½” perforated pipe wells, from June 2014, through three years after construction.

- Vegetative productivity - Three vegetative transects would be monitored at each meadow, located along existing topographic cross-sections, and following the USDA protocol for total plant production described in chapter nine of the Monitoring Manual for Grassland, Shrubland and Savanna Ecosystems (Herrick et al 2005) that is compatible with other SMRRP meadows.

- Community composition - Species would be grouped into wetland status following the Army Corps of Engineers State of California 2014 Wetland Plant List (Lichvar et al 2014), with the percentage of wetland plants compared before and after treatment. Transects would be monitored in early summer on an annual basis.

- Flow duration - Would be measured at the bottom of each project area with a HOBO data logger placed in the channel within a stilling well. Dataloggers would be installed as early as the project area is accessible in 2015, and downloaded monthly through the summer months until the channel is dry. 2015 would provide one year of pre-project data. The data loggers would be deployed for three years after construction.

- Wildlife habitat - Would be measured with bird point counts (Ralph et al 1997). One point count was conducted within the project area in 2014. Three to four additional point counts would be surveyed in spring and early summer 2015 under pre-project conditions and annually thereafter.

- Photo documentation - GPS'ed photo points would document overall changes in the vegetation and landscape. Pre- and post-project photos would be taken annually in mid-summer, and recorded with compass bearings.

8. ***Literature Cited:***

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