Section 5: Project Description

1. **<u>Project Objectives:</u>**
   The goal of the project is to restore and enhance meadows and the drainage in Truckee Meadows Restoration Project (TMRP). Please note that the Truckee Meadows Restoration Project has been referred to in the past as Truckee Wetlands Restoration Project.

The objectives are listed below.

Offset Greenhouse Gas Emissions through biological carbon sequestration (BCS) into vegetation, soils, woody products, and aquatic environments

Reduce Greenhouse Gas Emissions
Through completing restoration, GHG emissions are predicted to be reduced from the project area. Specific objectives include:

- Increase carbon storage in up to 13 acres of degraded wet meadow through improving plant vigor;
- Increase soil organic content in up to 13 acres of degraded wet meadow through extending the active plant growth season;
- Participate in Sierra Meadow Restoration Research Partnership, a Sierra-wide research project to assess effectiveness of restoration on GHG reduction.

Support Methods for Estimating Net Carbon (and CO2-equivalent) Sequestration
The overarching research objective of this project is to support development of methods for estimating net carbon (and CO2-equivalent) sequestration under pre- and post-restoration conditions for mountain meadows. The framework and methods employed in this project will be aligned with those proposed by other meadow restoration projects that represent a wide range of meadow conditions throughout the Sierra Nevada under the Sierra Meadow Restoration Research Partnership (SMRRP). Specific research objectives include:

- Determine potential contribution of GHG emissions to the overall carbon budget for project meadow and other meadows of same hydro-geomorphic type, geographic areas (climate, growing season), and parent material represented by this project area by measuring changes in soil carbon and peak GHG emissions under un-restored and restored conditions;
- Support development of parameters and proxy variables that will be used to build a model to estimate meadow carbon sequestration and GHG emissions by measuring soil organic carbon and GHG emissions along gradients expected to control GHG flux, such as depth and duration of saturation, soil texture and carbon content, plant community type, and length of growing season

Co-Benefit – Meadow Habitat and Drainage Restoration/Enhancement
Restoring function will improve meadow habitat and wildlife habitat, and provide other co-benefits such as recreation and education opportunities. Project objectives related to co-benefits include:

- Improve hydrology of 13 acres of meadow
- Increase area of attenuation in the restored and enhanced meadows and expanded pond
- Expand meadow and riparian habitat area by approximately 1.5 acres
- Reduce Erosion/sedimentation to downstream and the Truckee River by spreading flows from approximately 0.5 acres of existing drainages onto the meadows
- Ameliorate impacts of climate change through reducing flooding caused by rain on snow events
- Redirect flows currently flowing and eroding approximately 0.25 acres of upland habitat, into drainage course
- Create recreation/education opportunities

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

Background

The Truckee Meadows Restoration Project focuses on a degraded meadow and drainage complex in the Town of Truckee which confluences with the Truckee River. None of the meadows and wetlands within the fragmented complex are fully functioning. They are degraded due to disconnected hydrology, significant storm water runoff, significant erosion and inappropriate historic land use.

However, previously completed Feasibility (Balance Hydrologics 2010) and Assessment (Balance Hydrologics 2014) studies demonstrate enough of the complex remains along with significant opportunities for re-connecting the hydrology that 13 acres of wetland and meadow can be restored and 1.5 acres of meadow habitat can be increased.

The Truckee Meadow Restoration Project is located within the Old Brockway Road Meadow Complex along Brockway Road in the Town of Truckee on the south side of the Truckee River, as shown in Figure 1 – Project Location and Figure – Site Map.

Surface water originates from developed springs and hillslope seeps, precipitation, and flows from west to east across a gently sloping terrace ranging in elevation from 5,880 feet to approximately 5,850 feet. A shallow pond located at the east end of the terrace, supplements spring-fed inflows with groundwater pumped from a nearby well. The pond drains through two outflow channels, across a meadow, to a relatively steep channel that routes flows north through a residential area and the Town of Truckee Corporation Yard, before discharging into the Truckee River at an elevation of 5,750 feet.

The Assessment concluded that the Hilltop-Ponderosa area of the TMRP was once a single connected wetland complex that discharged to the Truckee River, but has since been impacted by land uses and urban development within the Town of Truckee. Potential restoration strategies and alternatives have been identified for specific areas.

Existing Conditions and Recommended Restoration Concepts

The Assessment conducted describes the existing conditions of the meadow system in the project area:

- The current meadow form appears to be dominated by a bedrock or ‘strath’ terrace overlain by a thin veneer of glacial outwash. Meadow hydrology is seasonal, with groundwater levels falling to more than 5 feet below the ground surface in many locations by mid-July. Late summer groundwater conditions are supported primarily by the developed springs and irrigation ditches with limited influence from the Irrigation Pond. Re-establishing surface water connections across the meadow, ditch, and pond is likely to re-establish wetland conditions across impacted meadow areas.
- Wetland restoration efforts should therefor utilize surface flow as the primary mechanism to distribute water across the meadow.
- Soil stratigraphy in the Wetland Terrace Complex consists of historical wetland soils (silty loam) overlying clays, with artificial fill present in portions of the site, north of the Irrigation Pond and south of Estates Drive. Removal of fill and exposure of historical

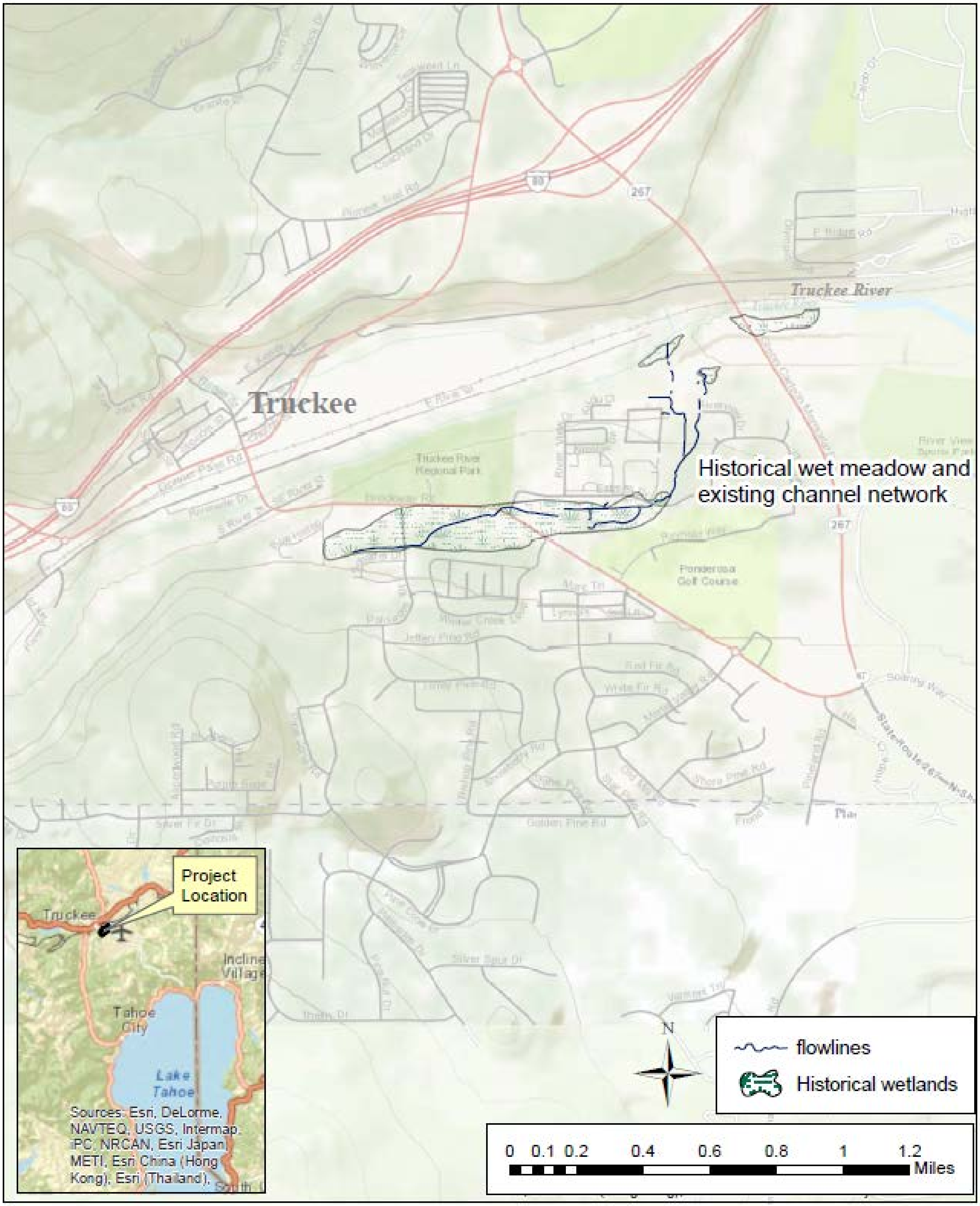

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Figure 1. Project Location, Truckee Wetlands Restoration Partnership, Truckee, California

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TruckeeRiverWatershedCouncil
Collaborative solutions to protect, enhance and restore the Truckee River Watershed

Figure 2. Site Map
Truckee Meadows Restoration Project

(12/18/14)

- wetland soils is anticipated to be a suitable wetland restoration approach in these areas.
- Water year 2013 has been characterized by very little precipitation after December. Results of the groundwater and surface-water monitoring program, however, indicate that spring-supported flows to the meadow and Irrigation Pond remain fairly steady, on the order of 0.2 to 0.3 cfs during the summer months. This supply may decline during very dry periods.
- Groundwater monitoring in the vicinity of the Irrigation Pond reflects a disturbed meadow system. During the winter months, saturation is relatively widespread, except for areas bypassed or drained by ditches, most notably west of the Irrigation Pond. During the summer months, the ditch and the pond hold water at elevations above the surrounding shallow groundwater table.
- Fluctuating water levels in the pond do not readily transmit across the meadow; therefore, restored meadow hydrology is not likely to be adversely affected by continued operation and short-term water level fluctuations in the Irrigation Pond.
- Water balance calculations reflect a condition in which pond inflows were on the order of 150,000 gpd during the irrigation season, sufficient to meet the golf course irrigation demand of 120,000 gpd. After consideration of evaporation from the pond, surplus water of approximately 10-15 gpm is available to support downstream hydrology, rather than the roughly 100 gpm that would be available without irrigation demands.

Tasks Performed to Date
Since the initiation of the project in 2010, the following has been achieved:

Formed Partnership Agreement
Truckee River Watershed Council (TRWC) collaborated with and brought together landowners and land managers to form the Truckee Wetlands Restoration Partnership. Partners are Town of Truckee, Truckee Donner Land Trust, Truckee Sanitary District, Truckee Tahoe Airport District, Truckee Donner Recreation and Park District, Truckee Donner Public Utility District, and as convenor, the Truckee River Watershed Council.

Completed Feasibility Study
TRWC lead the implementation in 2010 of a feasibility study (Balance Hydrologics 2010). The study reviewed of existing studies, analyzed historical and current conditions (including soils and geology), and reviewed current and future land use. Findings include that habitat restoration/enhancement opportunities are available and feasible at the project sites.

Completed Assessment
TRWC lead implementing an Assessment of the project sites (Balance Hydrologics 2014). Through analysis of soils and hydrology (soil and hydrological data collection), constraints were identified, conceptual restoration designs for five sites were created. All partners agreed to proceed with some agreement of cost sharing of in design, implementation, and maintenance.

Developed Conceptual Designs and Constraints
As part of the Assessment, conceptual drawings were created for all five sites of the project. Concepts include habitat restoration and enhancement, modifications existing drainages (ranging from modification to elimination), redirecting drainage out of upland areas, as well as options for interpretative trails and signs.

In progress - 100%Designs
TRWC is leading the development of 60% and 100% Construction Documents. The target date for completion is December 2015.

Conceptual model – Greenhouse Gas Reduction
We have developed a narrative conceptual model for how restoration is linked to reducing GHG emissions.

The distribution of vegetation types in mountain meadows reflects seasonal differences in ground water levels and litter decomposition (Allen-Diaz 1991, Merrill et al. 2006, Loheide and Gorelick 2007). Thus, hydrologically degraded Sierra meadows experience a radical change in plant community type distribution and overall plant biomass after restoration. In many cases, sparse cover of sagebrush, annual grasses, and forbs is replaced with dense thatch of sedge and willow species with similarly dense rooting structures (Chambers and Miller 2004, Lindquist and Wilcox 2000). In restored wet or very moist meadows, this change in meadow plant community structure co-occurs with an increase in net primary productivity and a decrease in aerobic decomposition rates of fine roots and above ground litter. These two changes (high NPP rates and slow decomposition) result in increased soil organic matter content representing carbon sequestration. Preliminary measurements of soil carbon in restored versus unrestored meadows in the Feather River watershed show that restoring meadows could provide a one-time increase in below ground C stores by 110 to 220 CO2-equivalent tons per acre over a 2 to 10 year post-restoration period (Wilcox et al. unpublished project results 2009). During the initial post-restoration years, these C sequestration numbers are very large and comparable to estimated rates of CO2equivalent sequestration reported for Delta fresh water wetlands and redwood forests (Miller et al. 2008, Miller et al. 2011, Knox et al. 2014).

Despite a paucity of existing data, the limited knowledge we have in these restored ecosystems is highly encouraging from a C-sequestration perspective. However, the net change in greenhouse gas (GHG) emissions from mountain meadows that occurs with restoration needs to be expanded to include fluxes of the greenhouse gases methane and nitrous oxide as well as soil carbon and carbon dioxide. The common unit, CO2-equivalents, is used to combine the radiative forcing effects of all greenhouse gases into a single value for any source, such as a wetland, forest, or manufacturing plant. Thus, net CO2-equivalents sequestered from a meadow take into account carbon dioxide uptake through photosynthesis and release to the atmosphere through respiration, as well as methane and nitrous oxide uptake and release to atmosphere. Net methane and nitrous oxide emissions from soils and sediment are critical because these gases, known to be important parts of the GHG budgets in other wetland types, have 25 and 298 times the radiative forcing of carbon dioxide, respectively, per mole of gas (over a 100-yr time horizon; Forster and others 2007). Unfortunately, the few studies that measured methane and nitrous oxide emissions from meadows covered only a narrow range of meadow types (Mosier et al. 1993, Blankinship and Hart 2014). In addition to being a potent greenhouse gas, nitrous oxide has other impacts on the biosphere: it is known to degrade ozone, but it also removes nitrogen from streams and standing water where this limiting nutrient can reach such high levels it becomes a pollutant.

In soils and sediments, nitrous oxide emissions typically occur as a result of two processes:

nitrification and denitrification. Nitrification is an aerobic, oxidative process that converts ammonium to nitrate. Nitrous oxide is produced by nitrification during the incomplete oxidation of ammonium to nitrate. On the other hand, denitrification is a reductive process, meaning it occurs in anaerobic environments by which nitrate is reduced to nitrous oxide and eventually to dinitrogen gas. The nitrous oxide produced by nitrification may be significant, but it is typically much less than the nitrous oxide produced in adjacent, anaerobic sites where denitrification is dominant. Thus, restoration from a very dry and well drained meadow to a moist and more productive meadow could introduce increased nitrification rates and associated nitrous oxide emissions. Areas of a hydrologically restored meadow where soil saturation remains high and organic matter is biologically available could support denitrification and associated nitrous oxide emissions. Similarly, in anaerobic conditions, decomposition of organic matter by soil microbes produces methane (methanogenesis). Therefore, with any increase in soil carbon accumulation due to restoration one must also carefully consider the production of methane and nitrous oxide to the environment. We do not mean to suggest that methane or nitrous oxide production are likely to cause restoration to be a net source of GHGs (measured in carbon dioxide equivalents to the atmosphere); however nitrous oxide and/or methane emissions could be a significant part of the overall GHG budget. Therefore the importance of their contribution needs to be determined and if needed, included in any predictive models used to assess carbon credits gained through mountain meadow restoration.

Through this research, we will test the hypothesis that: re-establishing the hydrological connectivity between the stream and the surrounding meadow will increase net carbon sequestration, taking into account net GHG emissions, compared to non-restored conditions. To test this over-arching hypothesis, we will measure net carbon sequestration in the Truckee Meadows Restoration project area under pre and post-restoration conditions and at the same time measure net carbon sequestration in a similar degraded and unrestored meadow, completing a before-after-control-impact experimental design. We will assume that the change in net carbon sequestration in the project area as compared to change in the unrestored meadow is due to restoration.

We will develop and apply the science to measure GHG (carbon, methane, and nitrous oxide) gains from restoration of Truckee Meadows Restoration wetlands. The same protocol will be applied to partner meadow-restoration projects in 2015 across the Sierras, and to type-matched degraded control meadows to clearly demonstrate effects of restoration on net sequestration. Other meadows will be added in subsequent years to include a full range of meadow types. Peer reviewed findings will be shared at an annual conference, developing a protocol to measure GHG dynamics and quantify the impact of restoration strategies on GHG capture in Sierra meadows.

Conceptual model – Project Success

TRWC follows a conceptual model outlined in Figure 3 for all our large scale restoration projects. The basics steps are:

- Assessment
- Feasibility Study
- Pre-Project Monitoring
- Project Design and Environmental Compliance

- Implementation
- Post-Project Monitoring
- Adaptive Management

We place an emphasis on process-based restoration "by understanding the underlying hydrologic, geomorphic, and biological conditions, restoration projects are designed to complement existing processes and success is much more likely." The Truckee Meadows Restoration project is designed to be consistent with meadow, drainage, and floodplain function that was lost as a result of interrupted, constricted, and redirected drainage flows when Old Brockway road, Estates Drive, adjacent development, and dirt roads were constructed. Following the steps in our model prevents a piecemeal approach to treating current conditions along the drainage from the meadows at the top of the project area to the outfall at the Truckee River.

Climate change considerations
Building resiliency in mountain meadow systems will help to alleviate impacts of climate change. We expect to see more rain on snow events and higher snow levels in the Sierra Nevada, leading to more flooding. The Truckee Meadows Restoration project directly addresses flooding impacts. At present, extreme high flows are confined to a single, undersized channel at the upper end of the project (Site 1), and also in Sites 3, 4, and 5. When flooding occurs, flows jump out of the channel (particularly in Site 3) and cause additional erosion in the existing channel and the adjacent meadow and upland habitats, resulting in loss of habitat.

Spreading out the flows that are confined to the straight channels, and installing structures to slow the water in these drainages, will eliminate impacts in the existing drainages and prevent future upland and wetland loss. The flows will be able to spread over a vast meadow area (Sites 1, 2 and 5) and be directed to the more natural drainage course (Site 3) and infiltrate instead of being concentrated. This will restore and enhance a significant area of meadows and floodplain habitat in the entire project area.

Linkages with other activities
The Truckee Meadows Restoration Project is included in the Sierra Meadows Restoration Research Project for analyzing greenhouse gas reductions. Other meadows included in the study are shown in Table 1. The data gained from this meadow will inform research and restoration activities throughout the Sierra Nevada.

The Truckee Meadows Restoration project is specifically referenced in several plans: Coordinated Watershed Management Strategy (TRWC 2010), and the Town of Truckee Brockway Trail Wetland Habitat Mitigation and Monitoring Plan, Nevada County, California (JBR Environmental Consultants, Inc. 2012).

Table 1. List of Meadows Included in the Sierra Meadow Restoration Research Partnership

Meadow Name	Proposed Study Type	Elevation (ft)	Primary Hydrogeomorphic Type	Secondary Hydrogeomorphic type
Bean Creek	State factor	3100	Riparian Low Gradient	Discharge Slope
Bear Trap	State factor	7000	Riparian Middle Gradient	
Clarks Meadow	Focus	5400	To be determined	
Deer Meadow	State factor	6250	Riparian High Gradient	Discharge Slope
Foster Mdw Lower	State factor	6850	Riparian Low Gradient	
Foster Mdw Upper	State factor	7100	Riparian Middle Gradient	
Freeman	State factor	6800	To be determined	
Greenville	Focus	5050	Riparian Low Gradient	
Loney	Focus	5990	Riparian Low Gradient	Discharge Slope
Mattley Meadow lower	State factor	7050	Riparian High Gradient	
Mattley Meadow upper	State factor	7100	Riparian Middle Gradient	
Middle Martis Valley	State factor	5850	Riparian Middle Gradient	
Osa Meadow	Focus	8500	Riparian Middle Gradient	
Red Clover-McReynolds	Focus	5600		
Truckee Meadows	State factor	5850	Slope Discharge	
Upper Goodrich	Focus	5200	Riparian Low Gradient	
Upper Loney	Focus	6031	Riparian Low Gradient	
Upper Truckee River Meadow	State factor	6240	To be determined	

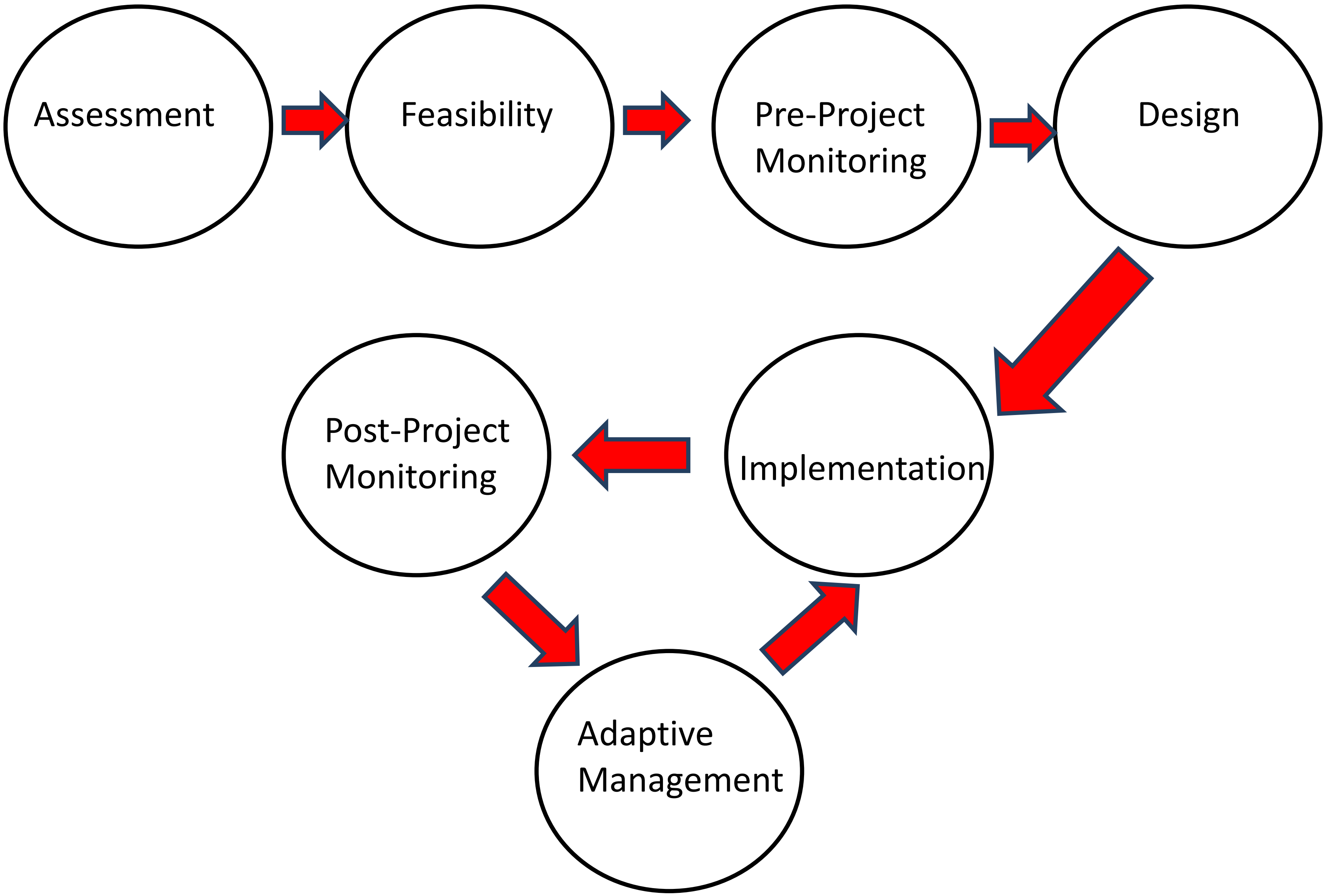

Figure 3. Conceptual Model: Project Success
Truckee Meadows Restoration Project

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

The TMRP will include restoration/enhancement of degraded meadow (Discharge Slope, Lacustrine Fringe, and Riparian High Gradient types), drainage, and floodplain habitats along an approximately 0.75 mile drainage course of a fragmented meadow complex and drainages that lead to the Truckee River. The proposed project consists of five Sites, encompass approximately 16 acres of meadow, drainage and floodplain that leads to the Truckee River (Figures 1 and 2).

Previously completed Feasibility and Assessment studies demonstrate enough of the complex remains along with significant opportunities for re-connecting the hydrology that 13 acres of wetland and meadow can be restored and 1.5 acres of meadow and riparian habitat can be increased.

Goals and measurable outcomes include the following:

- Reduce Greenhouse Gas Emissions by participating in Sierra Meadow Restoration Research Partnership, and by increasing carbon storage and soil organic content in up to 13 acres of degraded wet meadow through improving plant vigor and extending the plant growth season;
- Improve hydrology and increase attenuation in 13 acres of restored/enhanced meadow and increasing surface area around Irrigation Pond;
- Restoration of approximately 1.5 acres of meadow habitat;
- Reduce Erosion/sedimentation to downstream and the Truckee River by spreading flows from approximately 0.5 acres of existing drainages onto the meadows
- Redirect flows currently flowing and eroding approximately 0.25 acres of upland habitat, into drainage course;
- Ameliorate impacts of climate change through reducing flooding caused by rain on snow events; and
- Increase awareness wetland function, water quality, and habitat restoration through interpretive trails and signs

Proposed Restoration Elements

Restoration design of the Sites 1, 2, 3, 4, and 5 will yield plans to implement the following enhancement and restoration actions.

Disperse Flows Out of Existing Ditches and Eroding Channels Across the Meadow Surface
Currently, constructed ditches exist in Sites 1 and 2 that convey water from developed springs, under Brockway Road to the Irrigation Pond along Estates Dr. As a result of these ditches, much of the water that could be available to the meadow system is captured in these ditches and directed downstream to the irrigation pond. In order to reverse impacts associated with this feature, we propose installing several rock structures across the ditches in addition to filling the ditches to raise the flow line. The rock structures will slow the water, reducing erosion, and allowing water to spread across the adjacent meadow surfaces. The goal is to increase attenuation in the meadows and retain higher moisture content in the soils for a longer duration.

Increase Lacustrine Fringe, Discharge Slope, and Riparian High Gradient Meadow Habitat Around the Irrigation Pond

Currently, there is a band of lacustrine fringe meadow habitat and riparian (dominated by willows) surrounding a portion of the irrigation pond just south of Estates Drive (Site 2). A large area surrounding the pond is predominantly soil mounds with upland and some drier meadow species. The existing chain link fence around the pond will be removed, and the pond will be reconfigured with gradual side slopes to increase storage volume and provide a natural pond edge. Additional meadow and riparian habitats will be enhanced, created and restored.

Define Drainage Through Upland Areas

Currently, water runoff is conveyed from the natural habitat area just to the north of Estates Drive, north toward the Truckee River (just south of the Town of Truckee old corporation yard) (Site 3) in two shallow channels. One is over upland habitat and along a dirt road. Moderate grading will be conducted to define the drainage course to eliminate flows across upland areas. The rills and eroded areas will be restored by filling to grade and revegetating with native vegetation.

Enhance and Expand Ephemeral Drainage

Currently, water is conveyed via an underground culvert through the Town of Truckee dld corporation yard (Site 4). The culvert will be removed and a drainage course will be created to convey the runoff through the yard. The new drainage will be revegetated with native transitional riparian, meadow and other appropriate species creating additional habitat.

Restore Low Floodplain Terraces and Riparian High Gradient Habitat

Currently, the outfall in the drainage system enters the Truckee River through a culvert under the Legacy Trail (Site 5) via a concrete-lined rip-rapped swale. The natural floodplain and riparian habitat have been lost. Removal of the drainage swale and moderate excavation and reshaping will be completed to create a floodplain terrace at a suitable elevation to sustain potentially mountain alder, willow, and other riparian and meadow species.

Increase Infiltration (Decrease Runoff) at Parking Areas

Two existing unpaved (compacted soil) parking areas currently exist adjacent to the meadow system and pond along Estates Dr. Low impact development stormwater management features through the center island and around the parking lot edges will drain to the meadow to the east.

Trails and Educational Opportunities

Formal interpretive trails and signs are proposed for Site 1 and around the Irrigation Pond in Site 2. These trails will connect to the existing adjacent trail system adjacent to the sites. The improvements will provide access while limiting multiple informal access points and haphazard trail development. A trail is also proposed to connect the development south of Site 2, through the upland areas to Old Brockway Road. These trails are needed to direct pedestrians to use the upland areas rather than the meadow areas.

Project Tasks

Task 1.0 Greenhouse Gas Reduction Research Project
We will participate in Sierra Meadow Restoration Research Project (SMRRP, described in more detail under the "Project Approach" and "Research Component" sections below). Two types of research protocols are involved in the SMRRP; Old Brockway Meadows (Sites 1 & 2 of the Truckee Meadows Restoration project) will be included as a "state factor" meadow, which is subject to less intense monitoring. The two types of research protocol are described in more detail under "Research Approach".

The SMRRP will follow a "Before-After-Control-Impact" (BACI) study design; focus meadows will be sampled pre- and post-restoration (the "Before" and "After") and will be paired with a similar, degraded meadow (the "Control"), which will be sampled during the same time periods as the restoration focus meadow (the "Impact"). Measurements will begin in degraded control and restoration meadows prior to restoration in 2015, and continue at both sites throughout 2015 and into the spring of 2016. Although restoration activities, described under Task 3, will begin in fall 2015, changes in groundwater level and plant community composition are not expected to occur until the following spring and summer when the large influx of water from winter snow melt recharges local groundwater levels and occupies the restored channel. Spring 2016 sampling will effectively represent "pre-project" conditions.

<u>Task 1.1 Identify Control Meadow and Establish Transects</u>
Control meadows, with the same hydro-geomorphic class and in close proximity to the target restoration meadow, will be selected in the spring of 2015 for each restoration meadow. Paired control sites will be selected as meadows that have experienced hydrologic alteration and degradation similar to the target restoration meadow. There are several meadow sites within five miles of the project site that are likely to be appropriate. Pairing control degraded meadows with treatment meadows (i.e., restoration sites) will also provide controls on inter-annual variability that could confound effects of restoration. Restoration and control degraded meadows will be stratified according to hydro-geomorphic type as described in Weixelman et al. 2011 and then by dominant vegetation type (Sawyer et al. 2009). Three to four transects will be established across each meadow perpendicular to the dominant slope and to the degree possible, aligned with existing ground water well transects and positioned to capture the vegetation types covering the greatest surface area of the meadow.

<u>Task 1.2 GHG Measurements</u>
GHG fluxes will be measured by static chamber methodology (Hutchinson and Mosier 1981). Soil fluxes of carbon dioxide, methane, and nitrous oxide production will be measured as part of a complete soil GHG flux estimate. Ancillary data on ground water level, soil temperature, and water filled pore space will also be collected with the gas samples.

<u>Task 1.3 Soil Carbon and Biomass Production Analysis</u>
Soil carbon and biomass samples will be collected along transects established across the meadow (Task 1.1). Samples will be analyzed at a lab for vegetative carbon, soil carbon, and nitrogen.

Task 1.4 Incorporation of ancillary data

Hydrologic data (specifically shallow groundwater data) and vegetation data (Tasks 3.1 and 3.2) will be used to inform the results of the GHG measurements. Shallow groundwater wells (piezometers) and vegetation transects will be established in the control meadow to mimic transects already in place for the “impact” or restoration target meadow.

Task 1.5 Data analysis and reporting

The data collected for the Truckee Meadows Restoration project will be reported after each collection season to the SMRRP team and reviewed by a Technical Advisory Committee formed through the SMRRP.

Task 2.0 Prepare Monitoring Plan

We will prepare a monitoring plan that includes details on locations, type of sampling units to use for baseline (prior to construction), control, and restoration/enhancement (after construction) areas. Location and specification of groundwater monitoring piezometers to be installed will also be included. This plan will include example data sampling sheets, photo-monitoring data sheets, etc.

Task 3.0 Pre-Project Monitoring

Pre-project hydrologic monitoring and vegetation monitoring will take place under the CDFW funded portion of the project. Pre-project monitoring results will be summarized in an annual monitoring memo, submitted by the end of 2015.

Task 3.1 Groundwater Monitoring Devices

Currently, staph plates with water level recorders (gages) are installed to monitor flows at the outfall of select culverts and to monitor groundwater levels in Sites 1 and 2 (Figure 4). The results of the groundwater data gathered in 2013/2014 is shown in Figure 5.

To gather a complete set of baseline data for areas proposed for restoration/enhancement additional baseline monitoring devices (piezometers) and gages will be installed in the following locations:

- Site 1 - across drainage ditches to be filled and modified (piezometers)
- Site 2 - upstream and downstream of the Irrigation Pond (piezometers)
- Site 3 - upstream of the Old Corporation Yard (gage and piezometers)

Groundwater data collection will continue at all previously and additional placed groundwater monitoring device (gages and piezometers) locations through prior to construction and through post-construction monitoring. Groundwater will be recorded at each piezometer a minimum of once a month during the spring and early summer 2015 through December 2015. Groundwater may be recorded less frequently in the late summer to early winter months when levels are expected to drop below rooting depths.

Task 3.2 Pre-Project Vegetation Monitoring

In order to document successful establishment and change of vegetation establishment over time, baseline vegetation data will be collected prior to construction. In order to maximize identification to species, monitoring will be conducted between June and August 2015. Sampling methods will be stratified random placement of sampling units (quads or point intercept) in each habitat type and area, and it’s control location. The number and size of the sampling unit will be determined by the size and type of the habitat being monitored, and included in the monitoring plan. For example, for the meadow areas dominated by grasses and forbs, a pin frame or point- intercept could be used. A minimum of three sampling units will be placed in each meadow restoration/enhancement area. A botanist will be present while sampling to identify species.

We will conduct pre-project data collection (monitoring) during the growing season of 2015. Vegetation data will be incorporated into Task 1 (GHG reduction research project) as noted in Task 1.4

Task 3.3 Pre-Project Photo-Monitoring
Prior to construction, a minimum of three permanent photo-monitoring points in each meadow restoration/enhancement area will be established, that capture the diversity of each meadow area and habitat type being enhanced or restored. Photo-monitoring positions and bearing will be recorded on field base photo, using a hand-held GPS, and using permanent in-field markers such as grading/surveying feathers, small stakes, etc.

During the monitoring event, the following will be recorded: date, location, and bearing of each photograph.

Task 4.0 Technical Studies
The following technical studies will be conducted as required by CEQA and regulatory agencies. *All other studies required will be conducted but are not included in this grant application.*

- Biological Studies (Wildlife and Botanical)
- Wetland Delineation
- Cultural Resources

Task 5.0 CEQA
The Town of Truckee is the lead agency for preparing CEQA documents. We expect a Mitigated Negative Declaration will be required for this project.

Task 6.0 Permitting
The following permits are anticipated to be required for the TMRP. TRWC will coordinate with resource agencies and apply for applicable permits in 2015.

- Lahontan Regional Water Quality Control Board Permit – 401 Certification (Exemption possible)
- US Corps Permits (#27 Nationwide Permit)
- California Department of Fish and Wildlife Permit (Section 1602 Streambed Alteration Agreement) – Not expected to be required but will coordinate with CDFW
- Prepare SWPPP (Stormwater Pollution Prevention Plan)

Task 7.0 Construction
TRWC will contract with a qualified contractor to implement the TMRP. The following elements will be included in construction of each site.

Task 7.1 Site preparation
Site Preparation will include mobilization, staking grading limits and construction boundaries, removing non-native invasive plant species, etc..

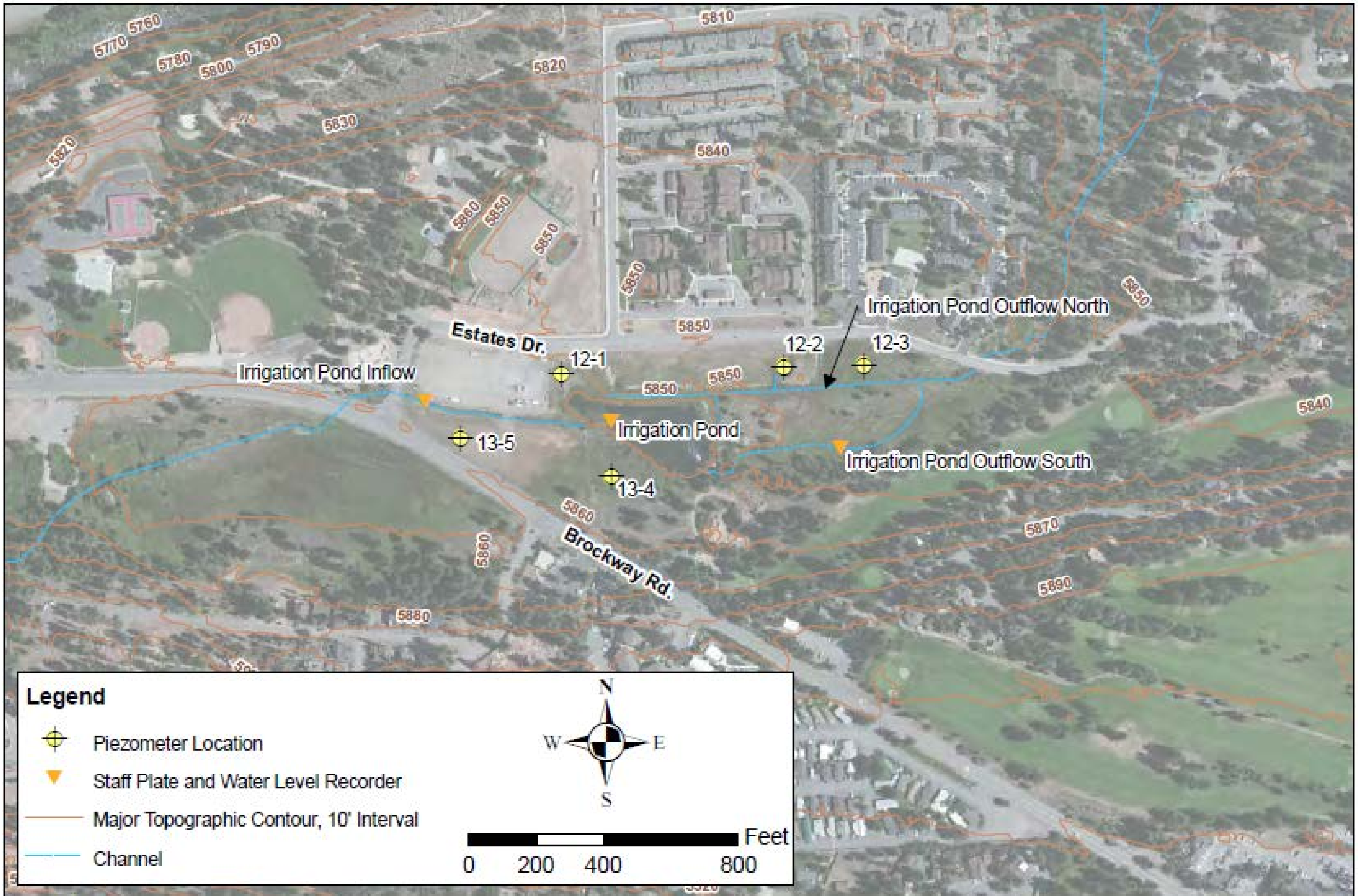

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Figure 4. **Surface water and groundwater monitoring locations, Truckee Wetlands Restoration Partnership, Truckee, California**

Basemap Source: ESRI

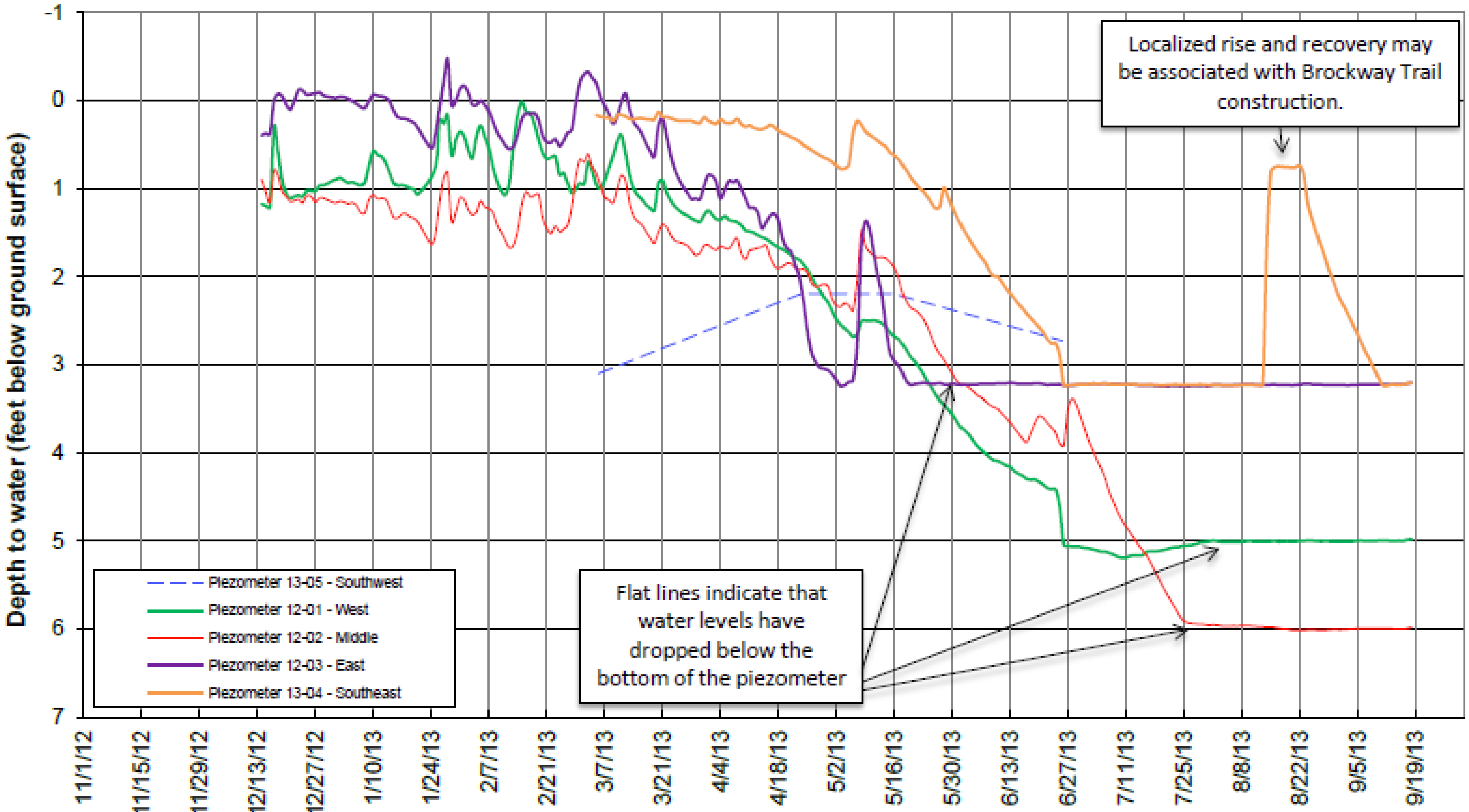

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Figure 5. **Depth to groundwater**
Truckee Wetlands Restoration Partnership, Truckee, California, water year 2013.
Groundwater levels were initially close to the surface, especially in relatively undisturbed meadow areas. Groundwater levels declined upon the onset of warmer temperatures and snowmelt, with more rapid declines in late April and early May

210028 SW + GW Obs Log.xlsx,Piezo DTW

Task 7.2 Earthwork
Earthwork will include clearing, salvaging and stockpiling meadow sod and trees, grading areas requiring recontouring the Irrigation Pond, hauling or transporting materials, fine grading for installation of trails, replacement of topsoil, etc.

Task 7.3 Revegetation
Revegetation will include labor and materials for replacing salvaged meadow sod placement, installation of cuttings, containers, plugs, and seed where and how specified.

Task 7.4 Rock/Boulder/Hard Materials Placement
Hard Materials placement will include installing rock/boulder/logs across meadow drainages, boulders for blocking access along roads, installation of drainage/culvert structures or similar, and installing fences and/or gates.

Task 7.5 Construction Trails/Walkways
Construction of Trails/Walkways will include placement of decomposed granite or other specified material on new trails/walkways and parking areas.

Task 8.0 Post-Construction Monitoring

Task 8.1 Post-project GHG emissions monitoring
The GHG and soil carbon measurements described under Task 1 will be repeated at both the restored/enhanced meadows, and the “control” meadow. Repeat sampling will take place in 2019.

Task 8.2 Post-Construction Success Monitoring
TRWC will conduct success monitoring on an annual basis following completion of construction. Success monitoring will include vegetation sampling for percent cover, and species composition, and compared to control sites (see Section 7. Protocols).

A wetland delineation will be conducted in 2019 to document total area of wetland created and enhanced.

Task 8.3 Post-project hydrologic monitoring
We will continue to monitor groundwater levels from the piezometers, and collect data from gages throughout the project site once a month and/or after large rain events from winter through summer, then less frequently from late summer through early winter.

Task 8.4 Post-project photo-monitoring
We will continue annual photo-monitoring of the project area after project implementation.

Task 9.0 Adaptive management
We will monitor the site for stability after construction. If any problems arise, we will develop a plan for corrective actions and implement them. Corrective actions may include additional heavy equipment work or additional revegetation. Data collected during post-project monitoring will also inform adaptive management actions.

Task 10.0 Stakeholder Coordination and Project Management
The Truckee Meadows Restoration project includes several property owners and

stakeholders. The stakeholder group has been actively involved in project design and will be involved through implementation and post-project monitoring. Stakeholder coordination includes regular quarterly meetings and supplemental meetings as needed.

Project administration consists of managing subcontractors, reviewing reports and data, participating in construction observation, invoicing, and preparing reports.

Project Approach and Project Objectives
The Sierra Meadow Restoration Research Partnership (SMRRP) works from the premise that re-establishing hydrological connectivity between the stream and surrounding meadow will increase plant biomass above and below ground, increase soil organic matter, and thereby improve soil capacity to sequester GHGs from the atmosphere.

The SMRRP leverages the considerable experience and expertise of academic and consulting scientists, practitioners and resource agencies to:

- Establish the scientific foundation for what drives variation in GHG emissions and net carbon sequestration across a range of Sierra meadow types;
- Standardize field sampling, lab methodologies, and data analysis procedures for GHG measurements;
- Develop a predictive model for net carbon sequestration in Sierra meadows and an associated quantification protocol.

The SMRRP also leverages a wide range of meadow types, locations, and conditions that will provide a 'gold mine' of information on the range of variability and associated controls on GHG emissions in the Sierras (Table 1). Information on GHG emissions and factors that control emissions from micro-site conditions to plant community scales will be collected at these sites and used to develop a predictive model for meadow carbon sequestration that is robust for the entire Sierra region. Finally and very importantly, through the process of implementing this project, the partnership will build regional and local capacity to monitor (and predict, using quantitative models) carbon sequestration and GHG emissions in meadows across the Sierras.

We have high confidence in the success of the Truckee Meadows Restoration project because the design comes from a watershed-process based background. We have put significant effort into project feasibility analysis (Balance Hydrologics 2010), Truckee Wetlands Restoration Partnership.Conceptual Design Basis Report (Assessment) (Balance Hydrologics 2014), and conceptual project design (Attachment 1). Re-watering historic wetlands will result in increase plant vigor (and therefore, increased GHG uptake), reduce flooding and erosion, and improve fish and wildlife habitat.

Our project implementation conceptual model allows us to specify project objectives through assessment and pre-project studies and then document whether or not our objectives were met through post-project monitoring. We have established baseline data for key parameters relating to expected project benefits.

Research Component
Participation in the SMRRP. The SMRRP was formed to provide a robust and coordinated regional response to the historic opportunity that AB 32 presents. The SMRRP is composed of a wide variety of agencies, organizations, and academic institutions (listed

below) and represents a potential research sample of approximately 20 Sierra meadows in 2015. The SMRRP will work together to advance our understanding of GHG dynamics in Sierra Nevada meadows and address the meadow restoration needs prioritized in the CA State Water Action Plan.

The SMRRP will leverage data from a wide range of member meadow types, locations, conditions, and predictive variables for a robust assessment of variability on GHG emissions in the Sierra Nevada. The SMRRP will provide members with peer reviewed and standardized field sampling protocols, lab methodologies, and data analysis procedures for GHG measurements, allowing for a comparative analysis of meadows across the Sierra Nevada.

To coordinate the efforts of the SMRRP, CalTrout will facilitate the quarterly meeting of a technical advisory committee (TAC) comprised of Consulting Scientists and SMRRP partners to coordinate projects, develop methodologies, integrate and analyze data, train regional practitioners in sampling procedures, and develop a predictive model to be submitted for approval by CAR, ACR and VCS.

SMRRP partners include: American Rivers, California Trout, Plumas Corporation, Sierra Foothill Conservancy, Spatial Informatics Group – Natural Assets Laboratory, South Yuba River Citizens League, Stillwater Sciences, Truckee River Watershed Council, University of Nevada at Reno, University of California at Merced, University of California at Davis, Tahoe National Forest, Sequoia National Forest, and others.

Research Approach
The proposed research will address the basic question: How does restoration of mountain meadows alter carbon sequestration in these ecosystems? We will address this broad question by collecting two sets of data at complimentary temporal and spatial scales. The first data set will be applied to **state factor meadows**, and will address the question of how state factors (Jenny 1994), including climate (elevation and latitude), parent material, topography (slope and aspect), vegetation zone, and time since disturbance, affect carbon sequestration and GHG emissions. Effects of these state factors will be addressed by measuring GHG emissions and associated field characteristics at coarse temporal yet fine spatial scales in SMRRP meadows representative of the range meadows across the Sierra Nevada. The second data set will be collected in **focus meadows** in order to (a) build robust annual GHG emission budgets that will inform annual estimates for other sites, and (b) to characterize key fine-scale hydrologic, geomorphic, vegetative, and biogeochemical parameters that relate to soil GHG fluxes. Information gained from this two-pronged approach will be used in order to create an empirically based model that can accurately predict the effect of restoration on soil GHG fluxes and carbon sequestration in meadows throughout the Sierra Nevada. Data from the proposed project will be made available to the entire SMRRP team to support development of the predictive model for meadow carbon sequestration.

Data from the state factor and focus meadows will be combined to establish quantitative relationships between readily measured proxy variables and carbon sequestration and between proxy variables and GHG emissions in Sierra meadows. These relationships will be used to build a model that estimates carbon sequestration and GHG emissions from un-restored and restored meadows in different parts of the Sierra Nevada. This draft model will be validated using emissions and sequestration data collected at a subset (at least one meadow complex) of the state factor meadows that will not be included in the development of model parameters. The quantitative model will build into a proposed carbon credit protocol for meadow restoration through the SMRRP. CalTrout will work with the California Air Resources Board to certify the protocol once it is developed through the meadow restoration projects implemented by SMRRP members.

Personnel

The program manager is Jeannette Halderman. Jeannette is responsible for participating in the SMRRP greenhouse gas project, overseeing monitoring activities, completing project permitting, contractor selection, managing project implementation, and overseeing post-project monitoring.

Jeannette was the project lead for the Truckee Wetlands Restoration Assessment (Truckee Wetlands Restoration Partnership.Conceptual Design Basis Report), and Project Design. She has also overseen all the activities for the project. Jeannette has extensive experience implementing restoration projects and working with stakeholder groups.

Lisa Wallace is the Executive Director of TRWC. She will be responsible for contracting, financial oversight, and managerial oversight for all project tasks. Lisa has provided project oversight for all the restoration projects mentioned above.

Bonnie Riley is the bookkeeper for TRWC. She will manage project invoicing and bookkeeping.

Kathy Whitlow is the Office Manager for TRWC. She will assist with public outreach, including press releases, newsletter articles, and website updates for the project.

4. *Timeline:*

Activity	Start Date	Completion Date
Task 1.0 Greenhouse Gas Reduction Research project	June 1, 2015	August 31, 2019
Task 2.0 Prepare Monitoring Plan	June 1, 2015	July 15, 2015
Task 3.0 Pre-Construction Monitoring	June 1, 2015	August 31, 2015
Task 4.0 Technical Studies	June 1, 2015	August 31, 2015
Task 5.0 CEQA	June 1, 2015	December 31, 2015
Task 6.0 Permitting	June 1, 2015	April 30, 2016
Task 7.0 Construction	August 1, 2016	October 15, 2016
Task 8.0 Post-Construction Monitoring	June 1, 2016	October 31, 2019
Task 9.0 Adaptive Management	June 1, 2017	June 1, 2019
Task 10.0 Stakeholder Coordination and Project Management	June 1, 2015	February 28, 2020
Final Report	November 1, 2019	December 31, 2019
Final Invoice Submitted	February 28, 2020	February 28, 2020

5. ***Deliverables:***

Deliverables

- Monitoring Plan (Vegetation and Groundwater)
- Pre-Project Monitoring Report
- Technical Study Reports (December 2015)
- Final CEQA Documents (December 2015)
- Permits Acquired (May 2016)
- Construction documentation including pre-, during and post-construction photographs
- As-Built Drawings (December 2016)
- Annual Post-Monitoring Summary (December 2017, December 2018)
- Photo-documentation of any adaptive management actions
- Final Report for Greenhouse Gas Reduction Research project
- Final Post-Monitoring Report (December 2019)

Data Storage

All data collected will be stored on our website and made publicly available.

Data and reports from this project and the SMRRP will be uploaded to the Sierra Meadows Data Clearing House (http://meadows.ucdavis.edu/), hosted at U.C. Davis.

Data which can be accepted by State Database CEDEN will be submitted to CEDEN, and other databases as defined by CDFW.

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

As noted in the PSN issued by CDFW for this grant program, very little research on greenhouse gas reduction in mountain meadows has been completed. One study of soil carbon uptake was completed in the Feather River watershed (Plumas Corp 2010) which clearly demonstrated increased carbon uptake in restored meadow as compared to non-restored meadows. On average, carbon sequestration in restored meadow was 40 metric tons per acre higher than carbon sequestration in degraded meadows.

The research component proposed by the SMRRP aims to build on the Plumas Corp study and will include other greenhouse gases other than carbon. At this point in time we do not have enough background data to predict total reductions. Our conceptual model, described in Section 5.2 outlines the process by which restoration will lead to a net decrease in greenhouse gas emissions from the project area.

7. ***Protocols:***

Protocols for measuring GHG reduction

Work tasks for measuring GHG reduction are listed in Section 5.3, Task 1. The tasks are repeated here with more detail on the protocols to be followed.

1.1 Identify Control Meadow and Establish Transects

Paired control sites will be selected as meadows that have experienced hydrologic alteration and degradation similar to the target restoration meadow. There are several meadow sites within 5 miles of the project area that are likely to be appropriate. Pairing control degraded meadows with treatment meadows (i.e., restoration sites) will also provide controls on inter-annual variability that could confound effects of restoration. Restoration and control degraded meadows will be stratified according to hydro-geomorphic type as described in Weixelman et al. 2011 and then by dominant vegetation type (Sawyer et al. 2009). Three to four transects will be established across each meadow perpendicular to the dominant slope and to the degree possible, aligned with existing ground water well transects and positioned to capture the vegetation types covering the greatest surface area of the meadow.

1.2 GHG Measurements

The static chamber methodology (Hutchinson and Mosier 1981) to measure GHG fluxes has been used by others to measure GHG emissions in mountain meadows in the Sierra Nevada and Intermountain West, including SMRRP participants Sullivan (UNR) and Hart (UC Merced) in various ecosystem types (Sullivan et al. 2008, Blankinship and Hart 2014). Boardwalks will be erected each year along these transects in wet areas to avoid trampling meadow soils and to minimize methane ebullition (bubbling) into the chambers during incubation measurements (Megonigal et al. 2004, Teh et al. 2011). Use of chambers vs. the eddy covariance method (Hutchinson and Mosier 1981; Baldocchi et al. 1988) will enable us to measure both nitrous oxide and methane emissions, and to link emission differences to sub-meadow scale variation in site conditions. Chambers will be constructed of polyvinyl chloride (PVC) tubing and be approximately 30 cm in diameter to reduce the inherent spatial variability associated with soil gas fluxes (Sullivan et al., 2010). In the field, the vented static chambers will rest on PVC collars that are permanently installed 2-3 cm deep in the soil to reduce soil disturbance and plant root mortality associated with repeated chamber-based flux sampling. Collars will be installed at least one month prior to the first measurement to allow stabilization of the surrounding soil and vegetation. Collars will be beveled on the soil-facing edge to minimize soil disturbance during installation. Soil fluxes of carbon dioxide, methane, and nitrous oxide production will be measured as part of a complete soil GHG flux estimate. Ancillary data on ground water level, soil temperature, and water filled pore space will also be collected with the gas samples.

UNR (Sullivan) and UCM (Hart) will work with Stillwater Sciences in order to refine chamber sampling techniques and protocols for measuring GHG emissions. Stillwater, with assistance from UNR (Sullivan) if needed, will train Plumas Corp field personnel in GHG sample collection. Both Stillwater and Plumas Corp will collect GHG samples from the state factor meadows. GHG gas samples generated in this effort will be sent to and analyzed by the Sullivan lab at UNR and the Hart lab at UC Merced using gas chromatography.

1.3 Soil Carbon and Biomass Production Analysis

Soil carbon and biomass samples are collected along transects established across the meadow, as described above. Four one-foot square plots will be chosen along each transect, with each plot representing a soil/vegetation type. In the un-restored meadows, it will be necessary to ensure that plot locations do not interfere with potential design features where earth movement activities are planned. Within these parameters, sample plot locations are randomly selected. 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 pre-determined, definable 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, i.e. grazed or un-grazed is made, 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 (Blake, G.R., and K.H. Hartge, 1986) 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.

All samples are processed and tested at the Soil, Water and Forage Analytical Lab at Oklahoma State University (OSU) in Stillwater, OK. Processing entails grinding vegetation samples, and sieving soil samples using an ASTM#10 (2mm) 8” brass sieve. Vegetation carbon and soil carbon and nitrogen are all determined using a LECO TruSpec Carbon and Nitrogen Analyzer. Large organic material sieved and removed from the soil samples are tested with the vegetation sample. At least 0.5 pounds of soil per sample is needed for processing and testing. Bulk density samples are dried at 105^{o}C and dry weight determined from a digital scale to a resolution of one gram. All lab samples are shipped in bags provided by OSU. The lab at OSU has strict QA/QC protocols in place.

1.4 Incorporation of Ancillary Data

Piezometers and vegetation transects are already established in the restoration meadow. We will establish a monitoring program in the control meadow in June 2015.

Ground water levels will be recorded during each GHG measurement period. We will measure expected site-scale predictor variables from piezometers in each meadow, soil chemical and physical analyses (including soil pore water and soil temperature), vegetative productivity, soil carbon, and plant community composition.

1.5 Data Analysis and Reporting

Data analyzed and reported will include GHG emissions, biomass production, groundwater levels, soil carbon and water content, and soil temperatures for each GHG sampling date. Emissions will be summarized by vegetation /hydro-geomorphic type for the meadow as a whole, and by season (sample date). If feasible, emissions will be estimated to the full year. Statistical comparisons of the pre vs. post restoration GHG emissions and net carbon sequestration will be made using the control site data for inter-annual variation in climate.

Performance Evaluation of Co-Benefits – Vegetation and Habitat Restoration/Enhancement

Species Cover Protocol

The species cover protocol is used to assess the percent vegetative cover in the restored/enhanced areas. The vegetation in the restored/enhanced areas will be compared to percent vegetative cover (native and non-native species) of chosen control sites in a similar meadow and drainage habitats within close proximity of the project site. Appropriate control site(s) will be done carefully and with consideration o the project site and control site(s) hydrology, geomorphology, and vegetation dynamics. Baseline sampling will be taken prior to construction and used to compare annual data for a means of documenting progress.

In order to maximize identification to species, monitoring will be conducted between June and August. Sampling methods will be stratified random placement of sampling units (quads or point intercept) in each habitat type and area, and it's control location. The size of the sampling unit will be determined by the size and type of the habitat being monitored. For example, for the meadow areas dominated by grasses and forbs, a pin frame could be used. A botanist will be present while sampling to identify species.

Revegetation/enhancement objectives will be an upward trend in cover of native species, or an increase in wetland species cover in the case where wetlands are being enhanced, with a goal over 60% of the control site within two years after construction.

Photo-Monitoring Documentation

A minimum of three permanent photo-monitoring points will be established, prior to construction, that capture the diversity of each meadow area and habitat type being enhanced or restored. Photo-point positions and bearing will be recorded on field base photo, using a hand-held GPS, and using permanent in-field markers such as grading/surveying feathers, small stakes, etc.

Photographs from multiple permanent points will be taken during each monitoring event to document change over time. During each monitoring event, the following will be recorded: date, location, and bearing of each photograph.

Groundwater Monitoring

Piezometers will be installed prior to construction is select locations to monitor anticipated changes in groundwater levels. For example, a transect will be set up across the drainage to be modified in the meadow of Site 1, with an expectation of groundwater levels being elevated from current conditions longer into the summer months.

Groundwater will be recorded at each piezometer a minimum of once a month during the winter, spring, and early summer. Groundwater may be recorded less frequently in the late summer to early winter months when levels are expected to drop below rooting depths, for two years following construction.

Data Analysis

Vegetative cover data for each habitat type and area will be averaged and compared each year to baseline and control point data. Species composition will be recorded and summarized for each area as well. Plant species recorded will be identified as obligate wetland, facultative wetland and upland. The percentage of each wetland category for each habitat type in each area will be summarized annually and compared to baseline and cotnrol sites.

Groundwater levels will be graphed against baseline conditions and the results will be summarized annually.

Photographs will be layed out side by side for each year in progression to present a visual of change over time.

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