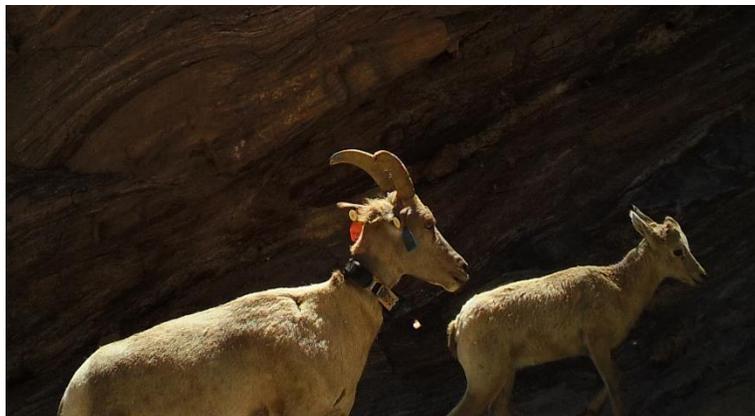**Coachella Valley Conservation**

March 13, 2020

Coachella Valley Multiple Species Habitat Conservation Plan & Natural Community Conservation Plan

Final Report for Local Assistance Grant P1786001: Determining Habitat Use and Response to Human Recreation Activities of Peninsular Bighorn Sheep in a Shared Landscape

Prepared by:

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Prepared for:
California Department of Fish and Wildlife

For the Period of May 1, 2018
to March 1, 2020

Abstract:

The Coachella Valley Conservation Commission (CVCC) was awarded $94,250 in funding through a Local Assistance Grant from the California Department of Fish and Wildlife (CDFW). The project "*Determining Habitat Use and Response to Human Recreation Activities of Peninsular Bighorn Sheep in a Shared Landscape*," focused on creating a preliminary study protocol to quantify Peninsular bighorn sheep (PBS) habitat use and the behaviors of human recreational users so that managers can better understand the interaction between the two groups. The goal of the project was to examine existing environmental data (vegetation, water sources, temperature, rainfall, vegetation, elevation, slope, habitat type, previous PBS locations and trail counters, and new data collected during the current LAG period from global positioning system (GPS) collars, infrared trail counters, and human volunteers (citizen scientists). Through methods identified in previous studies (Longshore et al. 2013) the study developed a protocol to document behavioral, temporal, and spatial responses of PBS to human recreational trail use (hiking, biking, horseback-riding) and determine whether trail use is presently causing temporary, permanent, or no detectable avoidance of habitat by PBS. The implementation of this protocol will enhance the effectiveness of ongoing monitoring of Peninsular bighorn sheep in the Santa Rosa and San Jacinto Mountains to meet recovery goals and adaptive management needs.

The CVCC, the implementing agency for the Coachella Valley Multiple Species Habitat Conservation Plan/Natural Community Conservation Plan (CVMSHCP/NCCP) worked with partner agencies including USGS, CDFW, USFWS, and BLM to implement this project. A grant agreement for P1786001 between the California Department of Fish and Wildlife and the Coachella Valley Conservation Commission was entered into on May 18, 2018. The term of this agreement was March 1, 2018 through March 31, 2020. This report covers the entire term of the project. The project area is within the Santa Rosa and San Jacinto Mountains Conservation Area of the NCCP, and also within the Santa Rosa and San Jacinto Mountains National Monument (SRSJNM). An unanticipated delay from the federal government shutdown in December 2018 through January 2019 as well as high turnover and loss of key agency partners resulted in delays in implementation of some parts of the project. As a result, testing of the protocol and collection and analysis of the data will be ongoing through the 2020 lambing season, resulting in a USGS final report and publication in September 2020. The recommendations from that report will assist with identifying needs for new satellite collar placement on PBS in the autumn 2020 capture and the requirements for a larger multi-year study on the effects of recreational use on PBS in essential habitat areas.

Project Summary:

This was a pilot study to examine habitat use by Peninsular bighorn sheep (*Ovis canadensis nelsoni*) in response to human related presence on recreational trails in the CVMSHCP/NCCP. Peninsular bighorn sheep are listed as a fully protected species in California, a federally endangered species, and a covered species under the CVMSHCP/NCCP. Under Section 7.3.3.2 of the CVMSHCP - Public Use and Trails Management within the Santa Rosa and San Jacinto Mountains Conservation Area (Trails Plan), and Section 8.4.7.1 Monitoring the Effects of Public Access and Use, land managers need to better understand the relationship between Peninsular bighorn sheep and recreational trail use through monitoring human use of PBS habitat and increasing use of trails by dog walkers, hikers, and bicyclists in the CVMSHCP/NCCP. Results from this pilot study provide critical information that will be used in a larger multi-year study to determine levels, timing, and locations of recreation that could cause negative effects to the landscape and PBS, and inform management decisions to deter negative effects in sensitive areas and promote recovery of this species. The goal of the pilot study was

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to analyze previous and new location data on the PBS population to determine baseline estimates of their spatial and temporal movement, identify and deploy equipment needs, and develop a vetted protocol. This protocol is currently being tested through the spring 2020 lambing season to document human recreation use with infrared trail counters and volunteers among nine trails in the Santa Rosa and San Jacinto National Monument.

A Technical Assistance Agreement #2018WSTAACVCC1 was approved between CVCC and the United States Geological Survey Western Ecological Research Center (USGS) on June 22, 2018. USGS was given access to layers of ecological data (previous PBS locations, dates, and times, possible lambing areas, vegetation and water resource locations, climatic information, trails and trail-use data). USGS, headed by Dr. Kathleen Longshore, conducted a thorough review of all previous data, including an analysis of approximately 400,000 collar location read-outs from radio and satellite collars, and pilot infrared trail counter data and locations. 210,000 GPS collar locations out of the previous locations were useable for the pilot study as they contained date and time stamps. These were collected primarily from 35 PBS collared between 2014-2019. During the initial months, the analysis narrowed the focus to nine trails that were in the vicinity of PBS collar locations, and nine Trafx infrared trail counters that were already installed. During the period of the study, CVCC ordered 15 additional infrared counters and BLM installed them in critical areas to determine the amount of trail use at the trailhead and interior of the trails.

The initial study suffered from a couple of setbacks. One of our most integral partners for this study, Dr. Chris Gregory of USFWS, passed away in the spring of 2018 just after the LAG grant was accepted and implementation began. Dr. Gregory had devoted an enormous amount of time attempting to coordinate and collect data from the earlier CDFW collars and studies. The loss of his knowledge and experience created a gap in knowledge regarding what data was available and how it could be used. Once the data was received in winter 2019, the initial analysis of the data was completed and a study design was created, with plans for testing to begin in the spring 2019 lambing season. Due to the federal government shutdown, there was a delay in the completion of the design and protocol, and it affected the completion of some of the anticipated outcomes for this project. The study design and protocol were instead deployed in the spring 2020 lambing season and will continue through May 2020. CVCC will fund the remaining months of the study to ensure the best results from the time and effort put into the initial study from all of the partners involved.

Project Implementation and Task Summary:

This section of the report provides a summary of the activities involved in project implementation and a review of the individual tasks that were set forth in the grant agreement. This pilot study was designed to detect short and long-term effects of disturbance by focusing on geographic areas where human recreational use occurs repeatedly during the cooler periods of the year, especially between January and April (lambing season), and to quantify changes in habitat selection that coincide with different intervals or time scales of disturbance. Specific questions for this research include:

1) How is Peninsular bighorn sheep (PBS) use of habitat near recreational trails influenced by human activity (trail use levels) and habitat conditions (terrain, veg type, etc.)?
2) If PBS are tolerant of recreational activity up to a certain level (threshold), can that threshold be detected near individual trails?
3) Do specific actions by humans (off-trail use, presence of dogs, etc.) result in changes in PBS behavior?

Using the GPS locations from sheep collared in fall of 2017, our objective was to compare habitat selection during different times of day and year that correspond to periods of high and low recreation trail use. Trail counters have documented approximately 700 (low use) to 61,000 (high use) users a year on the nine trails identified to be within the vicinity of the GPS collars. Recommendations from the final report generated by USGS will help to determine how the study design and protocol will analyze whether repeated periods of high and low outdoor recreation activity cause PBS to alter their habitat use and occurrence in these areas.

Task 1: Previous Data Review: Once Notice to Proceed was given, CVCC contracted with USGS to review all previously collected data (e.g., GPS locations, infrared counters, vegetation mapping, and water sources). Geographic Information Systems (GIS) layers and aerial photos were used to document the number and location of trails within the study area. This data was evaluated to identify the nine trails in the study, then partitioned into low, medium, and high use to determine where infrared counters could be added to better document recreational users and gaps in areas where GPS collars will needed to be deployed in fall of 2020 for the larger multi-year study. The results of the previous data analysis and review can be found in Attachment 1: "*Study Plan: Determining Habitat Use of Peninsular Bighorn Sheep in Response to Human Presence on Recreational Trails.*"

Task 2: Equipment acquisition and deployment: Accomplishments for this task included coordination with wildlife agencies to plan for a fall 2017 capture of bighorn sheep and placement of monitoring collars on a representative sample of ewes. Previous to the study, almost 70 PBS (including ~30% of female PBS) in the study area were outfitted with GPS collars. When the project began, USFWS and CDFW increased the number of bighorn sheep with GPS Satellite collars in this region. Twenty (20) Lotek Pinnacle Pro DM GPS collars, 12 of which were deployed specifically to fulfill the objectives of this study, were placed on females throughout the region allowing real-time downloads of their spatial and temporal movements by satellite. The collaring was completed during the autumn 2017, before the beginning of the project, to significantly enhance our ability to track sheep movement over time. Before the use of the new collars, data collection was limited to line of sight downloads from the collars, which required intensive field work by CDFW biologists. The GPS collars have a two-way satellite iridium link that makes it possible for data to be uploaded remotely via computer, not requiring a field visit, and allows the readout times to be altered in case a more frequent or less frequent readout was needed. This enabled the study to analyze movements of the sheep in real time, with location readings every 1.5 to 2 hours without the lag time required for the field work. CVCC funded the data plan for 12 collars. This information was critical to determine how sheep were reacting to high, medium and low use trails during the duration of the study. The range of locations for all of the location data (2013-2019) extended from the Palm Springs, California region to the Mexican border (Figure 1).

Figure 1. Over 200,000 desert bighorn sheep locations collected from GPS collars from 2013 to 2019.

A total of 210,000 GPS collar locations out of the previous locations were useable for the pilot study, as they contained date and time stamps. These were collected primarily from 35 PBS collared between 2014-2019. CVCC staff worked with Randy Botta and Heather Pert of CDFW, and Chris Gregory of USFWS, to determine the number of sheep to be collared. The project called

for 12 collars to be placed on females in Recovery Regions 1 to 4 (Figure 2). Collars were placed on bighorn sheep by CDFW staff and the capture followed established protocols approved by the Large Mammal Approval Committee to minimize impacts to bighorn sheep. GPS locations of collared sheep were taken automatically multiple times per day throughout the life of this study. The GPS collection schedule was programmed to incorporate times with daily periods of high or low trail use.
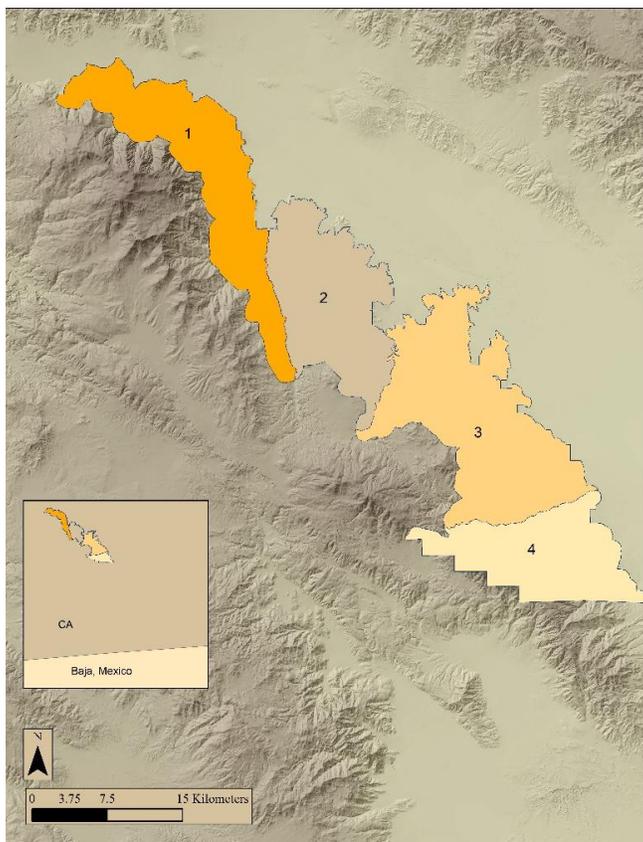

Figure 2. Recovery Region borders for the CVMSHCP.

Levels of trail use were collected by using remotely deployed Trafx infrared counters operating continuously at the trailhead and interior along the trail network and scored on their heaviness of use and type of use, as recorded by infrared counters (raw counts). Recreational use was documented through long-term deployments of these trail counters that have been placed on 26 trails from 2015 to the present. Of these, 16 have collected trail use data 24 hours a day for at least a full year. From these 16 trails, we selected nine of these trails to represent low, medium, and high-use areas near trailheads and approximately one kilometer from trailheads (Figure 3). After the initial analysis, BLM deployed 15 more infrared counters for further analysis of their use, bringing the total to 35 active counters throughout the study area. Previous to the initial study human observers visited the counters and counted the users to compare to the counters for calibration. Human counts are extrapolated based on infrared counter data. Observers in the form of citizen scientists were also deployed to test the protocol during lambing season in winter and spring of 2019 /2020. 15 additional counters were deployed during the duration of the pilot study. Also, once the protocol was developed, several human observers (citizen scientists) were deployed to document behavior (running, jumping, shouting) and record the numbers of dogs, bikes, up-and-back hikers, and other types of recreational users that the counters cannot detect.
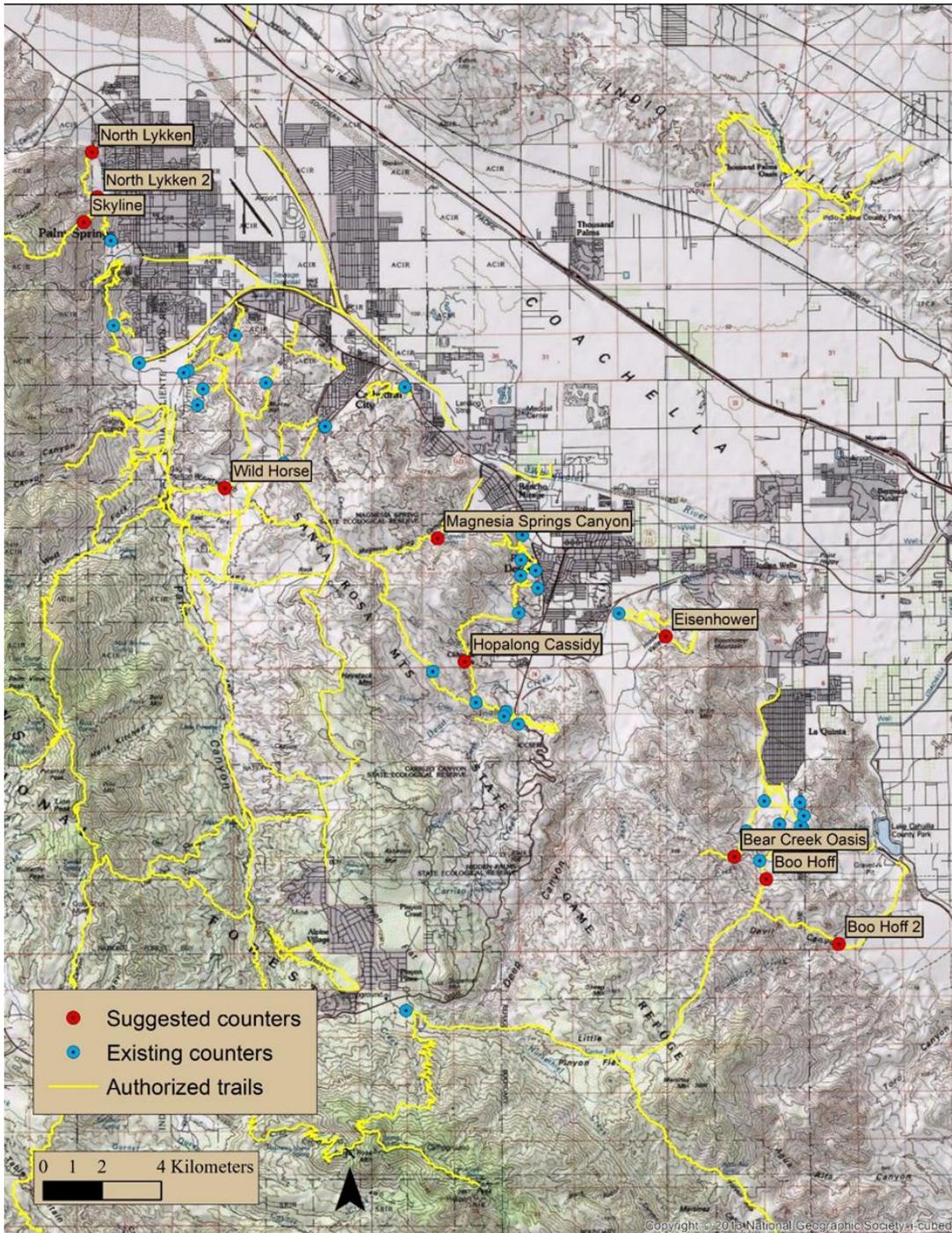
Figure 3: Map of existing and recently installed (suggested) recreation trail counters within the San Jacinto/Santa Rosa Mountain National Monument, Riverside County, California.

Task 3: Data Collection and Analysis:

Due to the federal government shutdown, USGS was denied the ability to collect data in the lambing season of 2019. Data collection is ongoing during the 2020 lambing season and will be completed in May 2020, with remaining analysis to be completed in summer 2020. The following are the methods used for collection and analysis:

Human activities will be documented simultaneously from the same nine trails described above and include walking, running, biking, or horseback riding. Deviation by persons from the trail (off-trail hiking) and the presence of dogs will be recorded.

Effects of Recreational Trail Use on Bighorn Sheep Habitat Use

Habitat use of collared sheep will be determined by measuring the following variables at each animal location and random point: slope, distance to permanent water, ruggedness, profile curvature, planform curvature, viewshed to a 75-m radius, distance from trails, and vegetation (four categories: low elevation shrub, high elevation shrub, tree, and cliff-sparse vegetation types) (see subsequent for variable descriptions). These variables have been documented as affecting bighorn sheep habitat use (Longshore et al. 2013). Lambing areas will also be identified by use of an R site fidelity (ewe clustering) program (Mahoney and Young 2017). Data will be separated into three seasons before analyses: spring = February through May, summer = June through September, and fall-winter = October through January. Data will be analyzed using a repeated-measures binary logistic regression (General Estimating Equation) with bighorn locations and random points as our dependent variable (Manly et al. 1993).

Description of Variables

Season: February-May (spring) was the period of greatest vegetation growth; June-September (summer) included high temperatures; and October-January (winter) was the period of greatest precipitation. Slope percentage: slope was measured with a GIS (ArcInfo 10.4) as a ratio of vertical rise/horizontal distance. Ruggedness: ruggedness was calculated with a GIS by measuring variation of the three-dimensional angles within each 10 x 10 m cell covering the study area (Sappington et al. 2007). Viewshed: viewshed was estimated for each animal and random location and calculated as the area within a circle (m^2) at a 75-m radius minus that area obscured from view by topography (Lowrey et al. 2019). Vegetation: low-elevation shrub, high-elevation shrub, tree, and cliff-sparse vegetation types derived and modified from digitized vegetation maps provided by the Coachella Valley Conservation Commission. Distance to water sources: water source locations were documented in 2014 by the Center for Conservation Biology at the University of California, Riverside. Curvature profile: the shape of the slope in the direction of the maximum slope. Negative values are upwardly convex, and positive values are upwardly concave. Curvature planform: The shape of the slope in the direction perpendicular to the maximum slope. Positive values are laterally convex, and negative values are laterally concave.

Using prior literature and expert opinion, we will form 10 candidate models designed to address the three research questions stated above. Candidate models will be ranked using an Akaike Information Criterion selection process (Burnham and Anderson 2002). The candidate models will be composed of variations from the following global model:

Relative probability of BH = Numbers of persons on trail (counter data) + BH distance from trail + lambing site type + trail name + slope + ruggedness + profile curvature + planform curvature + viewshed + veg type + distance to water + (BH dist to trail x counter data) + (slope x counter data) + (rugd x counter data) + (trail name x counter data) + (lambing site type x counter data)

We will use a logit-loglinear analysis to identify the relationship between bighorn sheep behaviors, human behaviors, and habitat variables.

The ten candidate models designed to address whether specific actions by humans (off-trail use,

presence of dogs, etc.) result in changes in BH behavior will be composed of variations from the following global model:

BH behavior (cat) = human behavior (HB)(cat) + counter data + trail name + slope + ruggedness + profile curvature + planform curvature + vegetation type + distance to water + (HB x trail name) + (HB x distance to water) + (counter data x trail name).

Task 4: Write reports and provide list of recommendations:

The project has had some very positive results and benefits despite the setbacks. The data gathered during this project provided an important analysis of what is known about the location of bighorn groups, including daily and seasonal variations in movement, vegetation and habitat use, and identification of possible lambing areas and sensitive water resources that require focused management. It has also identified high, medium, and low use trails to target the multi-year study in the areas where the transmitters can give us the most information on sheep movement. The protocol went through rigorous review and is completing a test run this spring to tease out any further areas of concern. A citizen scientist volunteer program was also set up with the help of the Friends of the Desert Mountains, CVCC's Trails Management Subcommittee and various hiker groups in the Coachella Valley to record behaviors of people and recreational activity use of the trails.

Although this is the final report for the LAG funded portion of this study, the complete final report will be published by USGS in September 2020. It will provide results of the analysis during the initial pilot study and recommendations to guide budgeting and management decisions for the forthcoming autumn collaring by CDFW and full implementation of the multi-year study funded through CVCC. The results will be presented to the Reserve Management Oversight Committee and Trails Management Subcommittee, including the Trails Research Working Group in our autumn and spring 2021 meeting to coordinate on any potential areas of concern. Although data collection will continue beyond the life of the LAG period, the final Study Design and Protocol provided by USGS are attached as appendices as final deliverables for this Local Assistance Grant. The USGS final report will also be sent to CDFW to attach to this report when completed.

Literature Cited

Burnham, K. P., and D. R. Anderson. 2002. Model selection and multimodal inference: a Practical information-theoretic approach. Springer Science + Business Media, Inc.

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Mahoney, P. J. and J. K. Young. 2017. Uncovering behavioral states from animal activity and site fidelity patterns. Methods in Ecology and Evolution 8:174-183.

Manly, B.F.J., McDonald, L.L., Thomas, D.L., 1993. Resource Selection by Animals: Statistical Design and Analysis for Field Studies. Chapman & Hall, London, p. 177.

Sappington, J. M., Longshore, K. M. and D. B. Thompson. 2007. Quantifying landscape ruggedness for animal habitat analysis: a case study using desert bighorn sheep in the Mojave Desert. Journal of Wildlife Management 71(5):1419-1426.

Budget:

-	Description	LAG Grant Budget	Total LAG Funds Spent	CVCC In Kind	Matching Funds
Task 1:	Previous data review and habitat evaluation	$34,225	$34,223.68	$0	$0
Task 2:	Equipment acquisition and deployment	$30,000	$8,166.00	$0	($35,359 CVCC); ($21,916 USFWS)
Task 3:	Data collection and analysis	$30,025	$30,026.32	$0	$0
CVCC funded	Data review and analysis	$0	$0	$9,508	$15,547.98
CVCC funded	Administration	$0	$0	$2,018	$0
TOTAL:	-	**$94,250.00**	**$72,416.00**	**$11,526.00**	**$57,275.00**

The total budget for Task 1 and 3 were both combined in the original grant agreement into the USGS contract for $64,250. A total of $34,223.68 were spent on USGS time for Task 1. Task 2 had budgeted $18,000 for the trail counters, $3,000 for the hardware, and $9,000 for deployment. A total of $8,166.00 was spent on Task 2, and BLM's rangers have had their time devoted in-kind for the data collection and deployment. A total of $30,026.32 was spent on USGS time for Task 3 for data collection during the LAG agreement. CVCC has spent and additional $15,547.98 on the USGS data collection, and $35,359 on collars. USFWS also devoted $21,916 to collars. CVCC staff also spent $9,508 on data review and analysis and $2,018 on administration for the project. A total of $74,416 was spent out of the $94,250 that was budgeted LAG funds.

Attachments:
1) Study Plan: Determining Habitat Use of Peninsular Bighorn Sheep in Response to Human Presence on Recreational Trails
2) PBS and Recreational Use Monitoring Protocol
3) CVCC Reimbursement Invoice # 20007-20