FINAL REPORT

December 2017

Innovative Restoration of Historic Wetlands Along Sulphur Creek, Valles Caldera National Preserve

Assistance Agreement CD#00F585-01-0 (FY2012)

Plug and pond structure, an innovative restoration technique designed and installed in Valle Seco at the headwaters of Sulphur Creek (July 2017)

New Mexico Environment Department

Surface Water Quality Bureau

Wetlands Program

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Project Goals and Objectives

The New Mexico Environment Department Surface Water Quality Bureau Wetlands Program (SWQB Wetlands Program), in cooperation with Valles Caldera National Preserve, Los Amigos de Valles Caldera, Albuquerque Wildlife Federation, the Defenders of Wildlife, an Albuquerque Boy Scout Troop, and other volunteers, have completed restoration of 41.6 acres of historic wetlands along Sulphur Creek in Valles Caldera National Preserve of New Mexico. This project was designed to develop and demonstrate the effectiveness of the plug and pond technique in headwater slope wetlands that were de-watered due to historic land uses.

The project goals include developing, implementing, and sharing the innovative technique widely so that it will be used on other slope wetlands, as well as prioritizing and planning for future wetland restoration in the Sulphur Creek watershed. Objectives for sharing information about slope wetlands included: 1) producing and distributing a Plug and Pond Technical Guide; 2) conducting volunteer workshop weekends where volunteers learned about the plug and pond technique and built ancillary restoration structures out of rocks and sod; 3) writing a report summarizing effectiveness monitoring data; 4) writing a summary technical article; 4) conducting a field trip to the project area; and 5) sharing project results in agency and organizational newsletters. The project also included the development of the *Sulphur Creek Watershed Wetlands Action Plan*, a collaborative effort by project stakeholders. The Wetlands Action Plan identifies restoration needs and proposed actions for the watershed.

Description of the Project

The SWQB Wetlands Program worked with Los Amigos de Valles Caldera and their subcontractors to design, construct and describe new techniques for restoring high elevation slope wetlands. A successful restoration project was completed that rewetted 41.6 acres of historic wetlands in the Sulphur Creek Watershed of Valles Caldera National Preserve. The project focused on developing the Plug and Pond Treatment Method. A total of thirty-two plug and pond structures were built. Ninety-three ancillary structures were also built, including: plug and spread structures, rock or sod Zuni bowls, one rock dams, rock rundowns, rock laybacks, media lunas, contour swales, rock laybacks, rolling dips, bypass channels, tree felling, and elk exclosure fencing. The project repaired incised channels and numerous headcuts to slow the flow of water, spread the water, raise the water table to re-hydrate historic wetlands, and increase water storage in the wetlands. For locations of the structures, see Figure 1 (Valles Seco) for the upstream area and Figure 2 (Sulphur Creek) for the downstream part of the project area.

Pre- and post-implementation monitoring was conducted between 2013-2017, including: 1) wetland delineation; 2) temperature data loggers installed downstream of the plug and pond structures to measure the presence or absence of water; 3) vegetation transects; and 4) repeat

photography at monumented photo points. Monitoring results demonstrated that the project was successful at spreading water and raising the water table, increasing acreage and abundance of wetland plants, and increasing the number of days per year that soils are saturated downstream of the plug and pond structures.

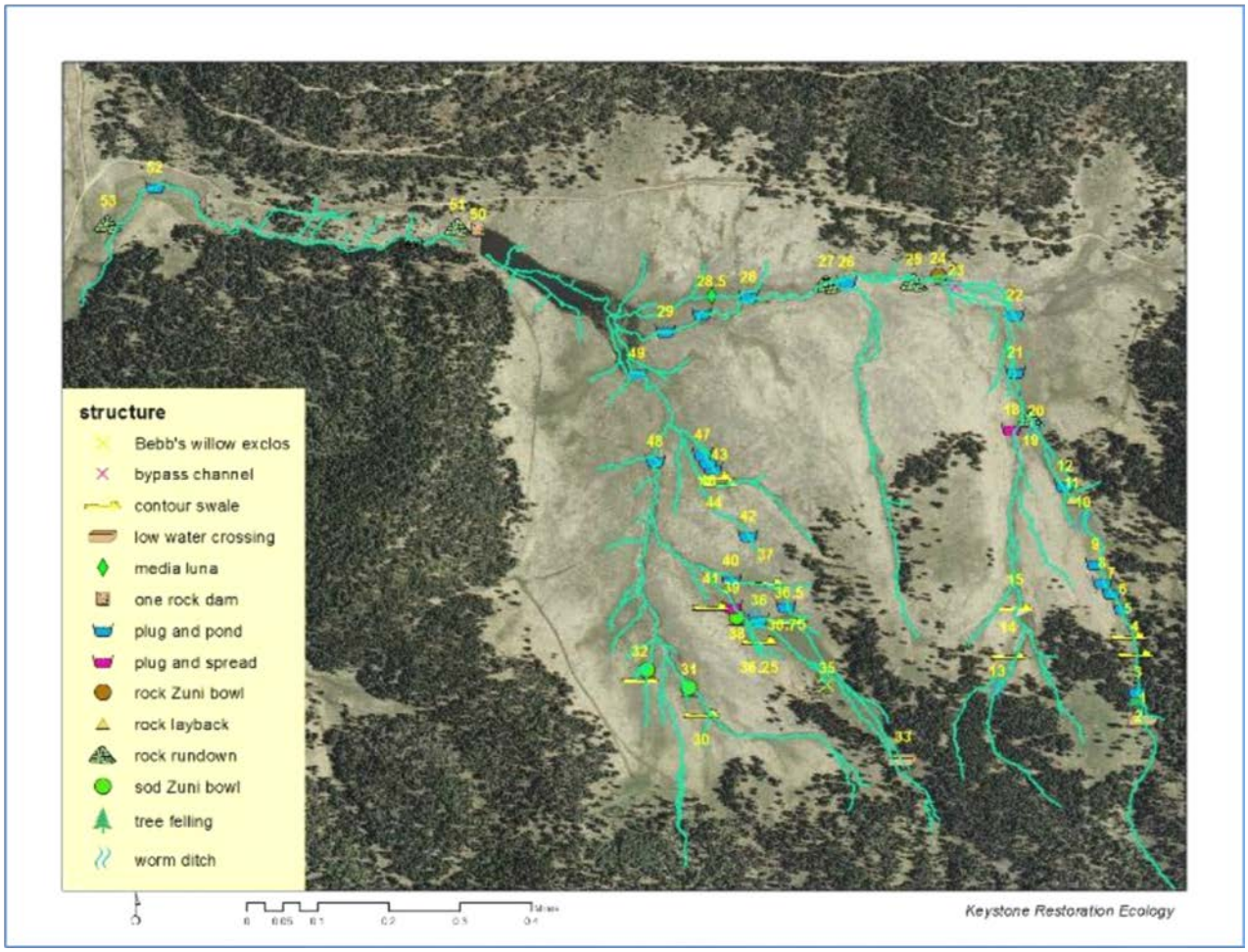

Figure 1. Map showing the locations of treatment structures and in the Valle Seco headwaters of Sulphur Creek. Tributaries are numbered 1-5 from left to right.

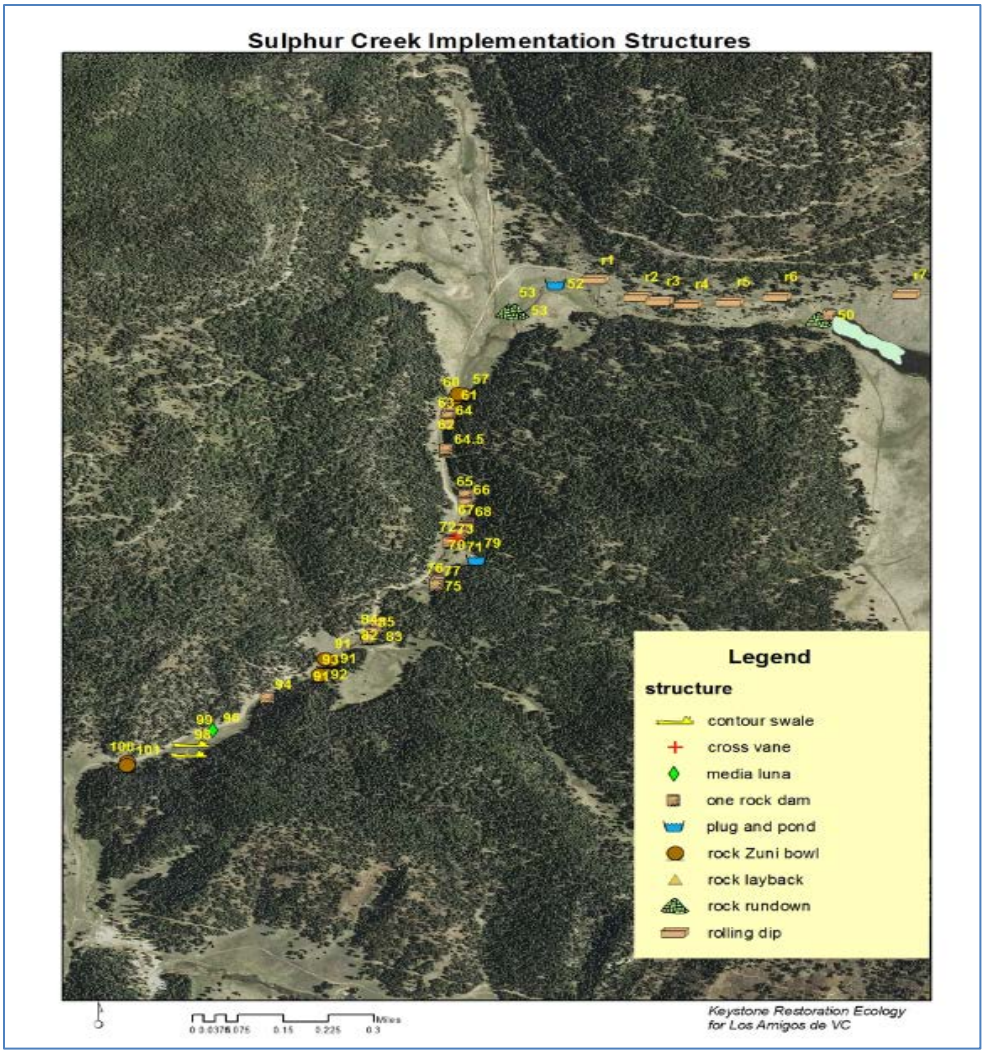

Figure 2. Map showing the locations of treatment structures along Sulphur Creek downstream of Valle Seco.

In addition to on-the-ground restoration, several documents were completed for technical transfer of project information and future wetland restoration efforts.

The Sulphur Creek Watershed Wetlands Action Plan (WAP) was written to identify wetland resources in the watershed and plan for their protection and restoration. The WAP describes the wetland resources and includes maps of existing wetlands, describes stressors, describes restoration/protection efforts, identifies restoration sites, stakeholders, prior watershed work, and lists potential funding sources.

The Plug and Pond Treatment: Restoring Sheetflow to High Elevation Slope Wetlands in New Mexico, by Bill Zeedyk, Steve Vrooman and Tamara Gadzia, is a wetlands technical guide developed through the project (referred herein as the Plug and Pond Technical Guide). This guide describes and illustrates the plug and pond treatment method, including design and construction

techniques, anticipated results and actual results. The guide highlights the project work performed in Valle Seco as well as prior wetland plug and pond projects along San Antonio Creek in Valles Caldera National Preserve.

Results of project effectiveness monitoring were compiled in a Sulphur Creek Monitoring Report and the information was condensed into a scientific article titled *Vegetation and Hydrology Response to the Restoration of Tributary Wetlands in Valles Caldera National Preserve Using the Plug and Pond Method*. The effectiveness of the plug and pond method was demonstrated through four lines of evidence: 1) Expansion of wetland acreage using wetland delineation protocol; 2) increase in wetland plant cover and species along transects downstream of plug and pond structures, 3) increase in the number of days per year that subsurface water is present downstream of plug and pond structures, and 4) repeat photography showing intact structures with standing water.

Figure 3. (left) Channelized flow in Tributary 1 of Valle Seco had desiccated historic wetlands (Fall 2014).

Figure 4. (right) A plug and pond structure at the same location has spread water across the valley and rewetted the wetlands in the foreground (Fall 2017). Both photos are taken looking upstream. Photos courtesy of Steve Vrooman.

The project resulted in the design of restoration techniques and the installation of restoration structures that were either new and innovative designs specifically for slope wetlands, or designs that were successful elsewhere and modified for slope wetland restoration.

The plug and pond technical restoration techniques and monitoring results were shared through five volunteer restoration work weekends between 2013-2017, through five Albuquerque Wildlife Federation newsletters, a field trip, presentations at two Jemez Collaborative Forest Landscape Restoration Program (CFLRP) Annual All-Hands meetings, and presentations at two New Mexico Wetlands Roundtables. Two hundred forty-five copies of The Plug and Pond Technical Guide were printed and distributed to landowners, land managers, watershed groups and restoration practitioners.

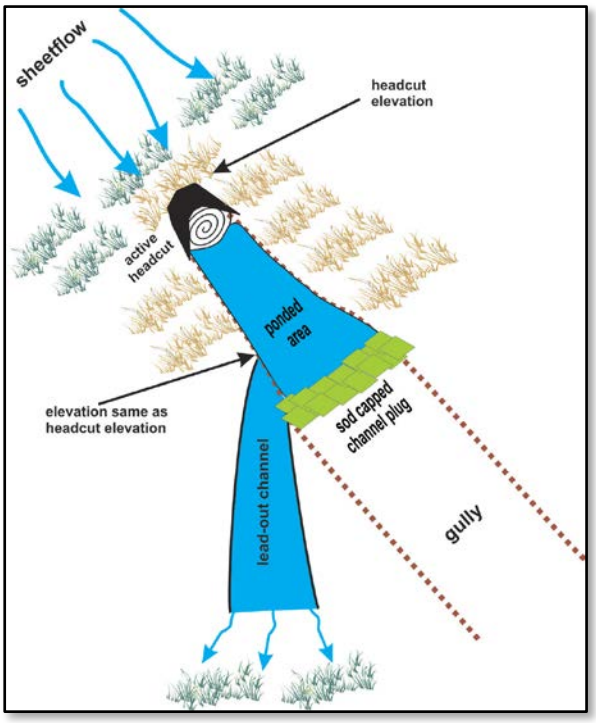

Figure 5. Diagram from the Plug and Pond Technical Guide of the plug and pond method as used for headcut control.

Project Outcomes

- At least 41.6 acres of slope wetlands were restored in Valle Seco and along Sulphur Creek, securing these critical headwater resources within the National Park System, improving water delivery downslope, restoring wetland habitat, and ultimately improving water quality and quantity in Sulphur Creek and downstream.

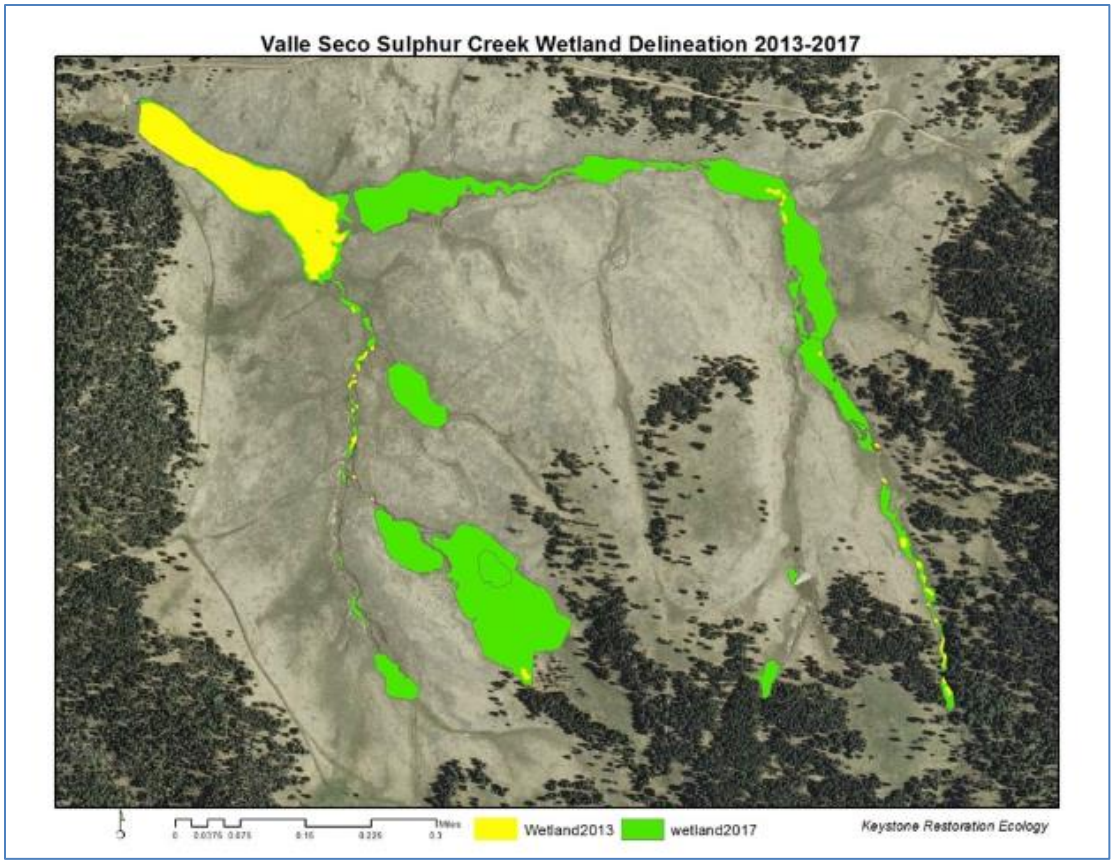

Figure 6. Map showing the increase in wetland acreage at Valle Seco before treatment (in yellow, 2013) and after treatment (in green, 2017). The large yellow area in the northwest corner is an historic pond.

- Over three years, hundreds of volunteer labor hours were donated during five weekend workshops, resulting in the training of dozens of volunteers in wetland restoration techniques and the installation of 93 ancillary structures along Sulphur Creek (ancillary to the 32 plug and pond structures). These events taught volunteers about how wetlands function, the importance of wetlands ecosystems, the need for restoration, and techniques they can use to monitor and restore wetlands.

Figure 7. Volunteers constructing a series of zuni bowls and one rock dams to stabilize the spillway of an historic pond at Valle Seco (June 2016).

- Twenty-one people attended a July 2017 field trip to learn about the plug and pond technique. The field trip included participants from federal and state agencies, profit and non-profit organizations, and the Board of Directors for Los Amigos de Valles Caldera.

Figure 8. Bill Zeedyk, Zeedyk Ecological Consulting, explains the function of a one rock dam on a field trip to Sulphur Creek (July 2017).

- Workshop and field trip participants included staff from the NM Department of Game and Fish, Lincoln National Forest in southern New Mexico, and Coconino National Forest in Arizona who will use the restoration methods on lands managed by their agencies.
- A total of 125 restoration structures were tested and monitored to determine their effectiveness, including: plug and pond structures, plug and spread structures, media lunas, worm ditches, and bypass channels for diverting and dispersing flow; one rock dams and tree felling to raise the bed of incised channels and restore sheet flow; Zuni bowls (rock or sod), rock rundowns, and laybacks to halt the progression of headcuts; and rolling dips and low water crossings to move water off the road. Elk exclosure fencing was constructed to protect vegetation. In many cases a combination of structures was constructed in series for the most effective treatment.

Table 1. Summary of restoration treatment structures constructed along Sulphur Creek.

Structure Type	Number of Structures
Bypass channel	1
Contour swales	20
Low water crossing	2
Media Luna	3
One rock dam	30
Plug and pond	32
Plug and spread	2
Rock layback	1
Rock rundown	7
Rock Zuni bowl	10
Sod Zuni bowl	3
Tree felling (multiple trees)	1
Worm ditch	5
Bebb's willow exclosure	1
Rolling dip	7
TOTAL	**125**

- 245 copies of the Plug and Pond Technical Guide were printed and distributed, providing targeted technical transfer to those who want to understand more about New Mexico wetlands. Conceptual designs for treatment are included in the publication. In addition to being distributed at a recent Roundtable that had 91 participants (January 18, 2018 Northern NM Wetlands Roundtable, the guide is available for download at https://www.env.nm.gov/wp-content/uploads/2018/01/Valle_Seco_Plug_and_Pond.pdf

- The Plug and Pond Technical Guide has also been distributed by the authors to the Natural Resource Conservation Service in Portland, OR and Dillon, MT; US Bureau of Land Management offices in Gunnison, CO and Dillon, MT; US Forest Service in Gunnison, CO; Colorado Parks and Wildlife Department; The Nature Conservancy Colorado Office; and several wetland consultants (in CO, NM and TX).

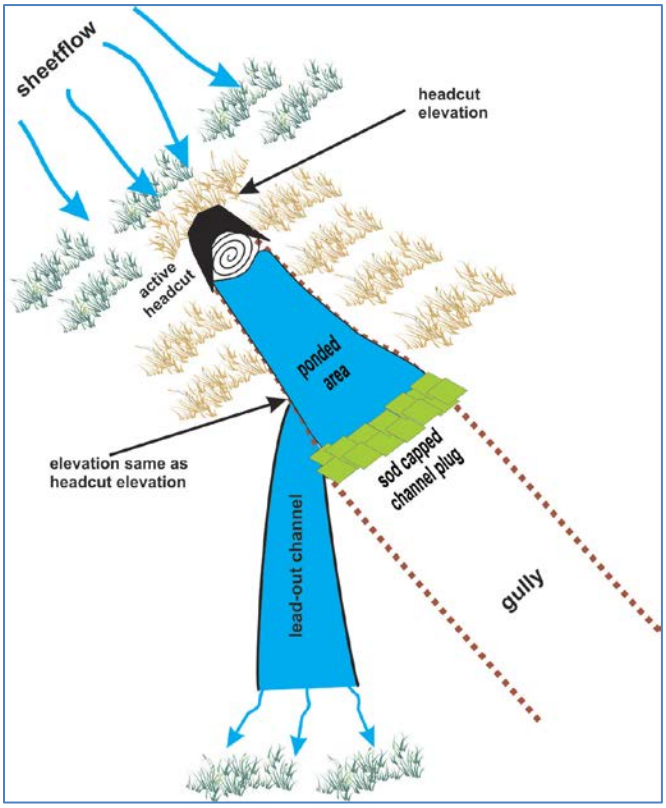

Figure 9. Schematic diagram from the Plug and Pond Technical Guide showing how a worm ditch can be used in conjunction with other treatment structures to divert water out of an incised gully or channel and spread it out again on slope wetlands.

- The Albuquerque Wildlife Federation included five articles about the project in their newsletter The Pine Cone (August 2015, September 2015, July 2016, August 2016 and September 2017).

- *Vegetation and Hydrology Response to the Restoration of Tributary Wetlands in Valles Caldera National Preserve Using the Plug and Pond Method* will be submitted for publication in a scientific journal.
- The ecological value of this project lies not only in the 41.6 acres of slope wetlands that were restored, but also in the replicability of this type of work at other locations. There are many slope wetlands in New Mexico that can be restored using the same techniques.
- The Redondo Creek project identified in the *Sulphur Creek Watershed Wetlands Action* Plan was selected for funding by the Rio Grande Water Fund – Stream Wetlands and Riparian Program.

Project Location and Previous History

Sulphur Creek Watershed is located in the Jemez Mountains of central New Mexico, on the west side of Valles Caldera National Preserve. The watershed is highly valued for its majestic views and recreational opportunities, such as wildlife viewing, hiking, fishing, and mountain biking.

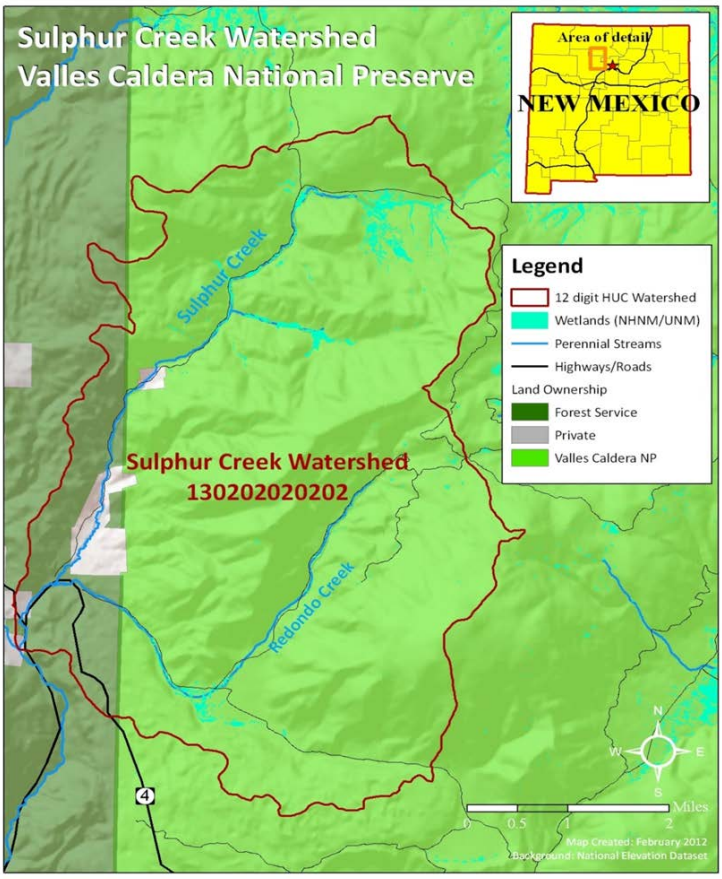

Figure 10. Sulphur Creek Watershed in the Jemez Mountains, New Mexico.

Sulphur Creek Watershed is typical of many areas that have experienced intensive historical use of the landscape, including clear-cut timber harvesting, heavy livestock grazing (sheep, cattle) and hydrothermal exploration. These activities resulted in the creation of numerous inadequately constructed and maintained roads, overgrazed grasslands, depleted vegetation in wetland and riparian zones, eroding stream banks and advancing headcuts throughout the watershed. The results of these land use practices led to an increased erosive tendency of the land. Many slope wetlands became channelized with numerous gullies that lower the water table and desiccate the wetlands.

Valles Caldera National Preserve was formerly the privately owned "Baca Ranch." The 89,000-acre property was purchased by the federal government in 2000 through the Valles Caldera Preservation Act and was managed by Valles Caldera National Trust for 15 years. VCNP became part of the National Park Service system on October 1, 2015 and has undergone new management changes, including the development of a Landscape Restoration & Stewardship Plan – Final Environmental Impact Statement and Foundation Document (currently in draft form) that addresses many land management and environmental issues on the preserve.

The National Park Service is committed to the preservation of water resources on Valles Caldera Nation Preserve and has been supportive of the New Mexico Environment Department and Los Amigos de Valles Caldera in completing the Sulphur Creek wetlands restoration work. Notable land changes that occurred during the project term included: the Thompson Ridge Fire that burned the area to the southwest of Sulphur Creek; and the permanent cessation of cattle grazing along Sulphur Creek.

Figure 11. Slope wetlands in Tributary 1 of Valle Seco at the headwaters of Sulphur Creek prior to restoration (Spring 2012).

Original Timeframe

The grant agreement for this project was approved on August 29, 2012 and was scheduled to be completed by December 31, 2016. The grant award was amended for a no-cost extension to December 31, 2017. The final year was used to: 1) collect wetland monitoring data to complete the monitoring report, Plug and Pond Technical Guide, and scientific article, 2) complete the Wetlands Action Plan, 3) conduct additional restoration activities during the summer of 2017, and 4) conduct additional outreach with project deliverables. In addition, the budget was amended to move funds from the Personnel category to the Contractual category to complete the additional restoration activities.

Partners Involved

Below is a list of partners involved in the project and their roles and contributions.

Contractor:

Los Amigos de Valles Caldera- Barbara Johnson (Project Manager 2013-2016);

Nina Wells and Peggy Gautier (Co-Project Managers 2017);

Jack and Darlene Crane (Volunteer Coordinators)

Land Manager - Valles Caldera National Preserve:

Scott Compton, Natural Resources Supervisor (Permitting, Planning, Implementation)

Jorge Silva-Bañuelos, Superintendent (Permitting)

Subcontractors:

Bill Zeedyk, Zeedyk Ecological Consulting (Design, Implementation, Volunteer Oversight, Technical Guide, Monitoring Technical Article);

Steve Vrooman, Keystone Restoration Ecology (Design, Implementation, Technical Guide, Monitoring, Monitoring Report and Monitoring Technical Article)

Van Clothier, Stream Dynamics (Implementation)

Tamara Gadzia (Technical Guide Design, Layout and Editing)

Dr. Kina Murphy (Monitoring, Monitoring Report and Technical Monitoring Article)

Dr. Jonathan Coop (Monitoring Report and Technical Monitoring Article)

Dr. Scott Collins (Monitoring Report and Technical Monitoring Article)

Casey Gierke (Monitoring Report and Technical Monitoring Article)

Albuquerque Wildlife Federation:

Michael Scialdone, Kristina Fisher, Cameron Weber, and many other volunteers (Implementation- volunteer labor).

Elk Valley Subdivision:

Jim Counce, Shawn Dietrich (Implementation- volunteer labor)

Albuquerque Boy Scout Troop: (

Several boy scouts (Implementation- volunteer labor)

Defenders of Wildlife:

Michael Dax (Implementation- volunteer labor and donated lunches)

Funding

The original federal funding amount was **$288,695.00** and the original pledged match was **$106,659.00**. The final federal amount spent was **$281,595.47** and the final match amount was **$125,307.65**. The final unspent federal funding was in the Indirect Category, which could not be re-allocated to spend in another category.

Project Highlights and Chronology

- The project was approved and funded by EPA on August 29, 2012 under Assistance Agreement CD#0F585010 (FY2012).

- Karen Menetrey, Wetlands Program Project Officer (WPO), and Maryann McGraw, Wetlands Program Coordinator(WPC) conducted an informal reconnaissance with Los Amigos de Valles Caldera and Valles Caldera Trust staff on September 13, 2012. We toured the creek, identified potential locations for restoration structures and discussed scheduling.

Figure 12. Looking upslope at a thin ribbon of slope wetlands (September 2012). An objective of the project is to increase wetland acreage laterally across the width of this valley.

Figure 13. Numerous small channels were draining the slope wetlands (September 2012). Plugging the channels would spread the water and expand wetland acreage.

Figure 14. Headcuts were draining the wetlands and would advance uphill if not arrested (September, 2012).

- Three wildfires in the Santa Fe National Forest severely affected accessibility to the national forest during Summer 2013 and one of these, the Thompson Ridge Fire, directly affected Sulphur Creek. The Thompson Ridge Fire started on May 31, 2013 and was not contained until July 1, 2013. The Burn Area Emergency Response (BAER) assessment team produced a burn severity map for the Thompson Ridge Fire (Figure 14). Approximately 74% of the 23,965 acres within the Thompson Ridge fire perimeter was either unburned or received a low-severity burn; approximately 23% sustained a burn of a moderate severity; and approximately 3% burned at a high severity. Access to the Sulphur Creek watershed was not allowed while the fire was active. Portions of the Sulphur Creek watershed were burned on the southeast east side of the creek, but remained unburned on the northwest side. The “Sulphur Creek” label on the map identifies the watershed (outlined in purple).

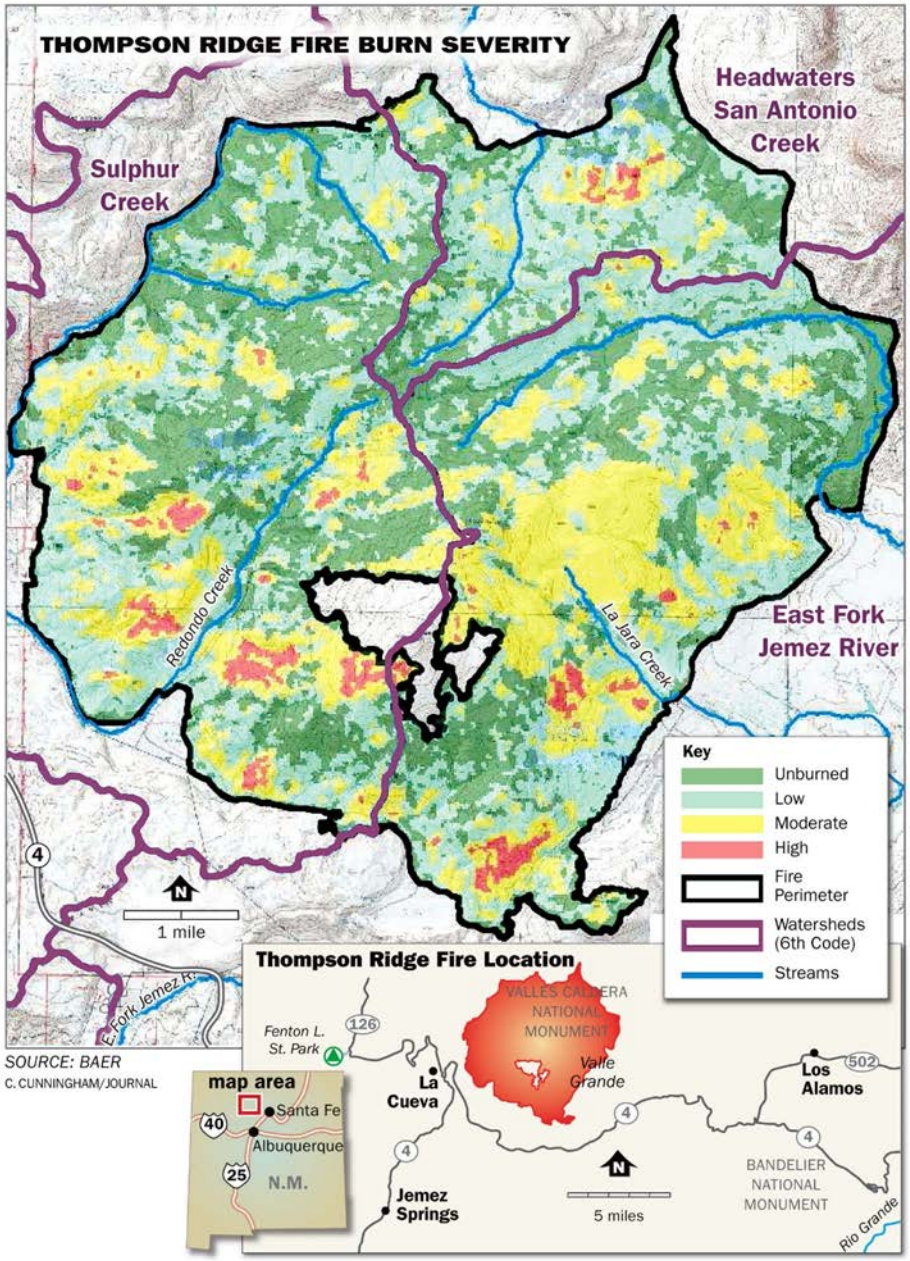

Figure 15. Map of Thompson Ridge Fire Burn Area and Severity, showing unburned, low, moderate and high-intensity burn areas (July 2013).

- The Thompson Ridge Fire subsequently impacted lower Sulphur Creek with flooding that caused both scour and deposition of ash, debris and sediment. Post-fire effects occurred predominately downstream from the project area. However, closure of the area delayed the Valle Caldera National Preserve's cultural resource survey to 2014. This survey was necessary to attain National Historic Preservation Act (NHPA) compliance prior to starting the wetland restoration project.

- NMED executed a sole source contract with Los Amigos de Valles Caldera on September 13, 2013.

- NMED submitted a Quality Assurance Project Plan (QAPP). EPA approved the QAPP (QTRAK #13-5110) on September 26, 2013.

- Compliance with the National Environmental Policy Act (NEPA) had already been completed in April 2009 per a *Finding of No Significant Impact and Implementing Decision, San Antonio Watershed – Wetlands and Riparian Restoration*.

- Steve Vrooman, Keystone Restoration Ecology, conducted pre-implementation monitoring in October 2013. Vegetation transects were established and pre-implementation wetland area was mapped using Global Positioning System (GPS).

- Bill Zeedyk, Zeedyk Ecological Consulting and Steve Vrooman, Keystone Restoration Ecology Restoration conducted design reconnaissance in October 2013. Areas of potential restoration activities were mapped using GPS and summarized in a table for the project Technical Steering Committee.

- The Technical Steering Committee met on February 20, 2014 to prioritize restoration work that could be completed within project budget. Attendees were: Karen Menetrey, NMED WPO; Barbara Johnson, Los Amigos de Valles Caldera; Scott Compton, Valles Caldera National Preserve; Jack Crane, Los Amigos de Valles Caldera; and Bill Zeedyk, Zeedyk Ecological Consulting. The committee reviewed maps and a corresponding table of 111 numbered sites in Valle Seco and along Sulphur Creek that were identified for treatment to protect or restore wetlands. At each site, a proposed treatment structure (or set of structures) was identified for implementation.

- A cultural resources survey was conducted by Valles Caldera National Preserve archaeologists during Spring 2014. The survey report did not identify significant areas of cultural resources in the project area.

- The Technical Steering Committee met on November 7, 2014 at Valles Caldera and finalized the priority sites for restoration. Priorities were to: construct plug and pond structures with machinery in the Valle Seco headwater area; construct hand-built structures with volunteers in the main stem of Sulphur Creek; and improve the road where runoff was negatively impacting wetlands.

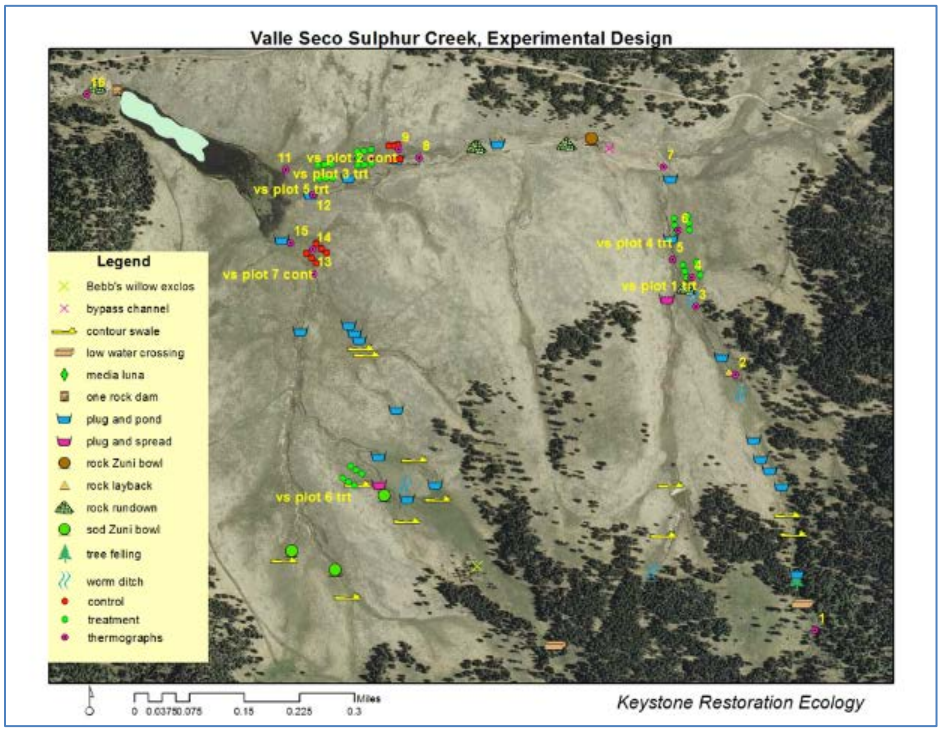

Figure 16. Design document for location of restoration structures and monitoring points in Valle Seco.

- In December 2014, the enactment of the National Defense Authorization Act for Fiscal year 2015 (Public Law 113-291) established Valles Caldera National Preserve as a unit of the National Park System (NPS). The legislation called for a period of transitional management that ended on September 30, 2015, after which the National Park Service assumed full responsibility for the Preserve. Los Amigos de Valle Caldera established a new memorandum of understanding with the NPS regarding their role in education, protection and restoration activities.

- On March 24-27, 2015, the WPO attended a four-day training in Prescott, AZ titled *Geomorphic Processes and Restoration of Natural Channels in the Arid Southwest*. The training included the classification system for rivers relevant to Natural Channel Design, (often referred to as Rosgen Methods). This intensive course covered valley type, stream type, longitudinal profiles, and cross-sections, as well as other stream data collection methods and a general overview of restoration techniques and principles for rivers, riparian areas, and wetland types such as wet meadows. The training is directly relevant to the classification, monitoring and restoration of wetlands for the Sulphur Creek project,

which relies on the principles of natural channel design. The registration fee and travel were charged to the Sulphur Creek grant.

- In Spring 2015, Valles Caldera National Preserve submitted a Clean Water Act (CWA) Section 404 permit application to the US Army Corps of Engineers (USACE). On June 25, 2015, the WPO and representatives of USACE, Valle Caldera National Preserve, Los Amigos de Valles Caldera, and Zeedyk Ecological consulting participated in a field inspection to support and provide information for the CWA Section 404 permitting.

- The first restoration volunteer work weekend was conducted on July 17-19, 2015 by Los Amigos de Valles Caldera and Albuquerque Wildlife Federation as match for the project. Thirty-seven volunteers attended. Because the CWA Section 404 permit was not approved prior to the workshop, the volunteers focused on restoration activities around the pond at the bottom of Valle Seco (the pond is historic, therefore it is grandfathered and did not require permitting). A large one-rock dam was built at the spillway, with a series of one-rock dams and Zuni bowls below the spillway. The purpose of this work was to slightly raise the spillway (by six inches) and fortify the spillway. Raising the spillway added a small amount of fringe wetland around the pond's perimeter, and fortifying the spillway protected wetlands upstream of the pond (if the spillway were to fail then all the upstream wetlands could be jeopardized by channel incision and headcuts).

- At the July 2015 workshop, volunteers also dug worm ditches upstream of the pond. The worm ditches are used to address erosion and expand wetland acreage. Instead of water flowing in a main channel, part or all of the water is diverted along contour upstream of a headcut, thereby starving the headcut of the water and energy required for its continued development. The sod dug from the worm ditch is then used to help repair the headcut, along with rock structures such as Zuni bowls. The sod has abundant strong rush and sedge roots that bind the structures in place.

Figure 17. Volunteers considering placement of a large anchor rock in a Zuni bowl. Geotextile fabric was laid under the zuni bowl to help capture sediment (July 2015).

Figure 18. Completed one rock dam and Zuni bowl (center of photo). The Zuni bowl is the same structure shown under construction in Figure 17 (July 2015).

Figure 19. Volunteers digging a worm ditch to re-route water in Valle Seco (July 2015).

Figure 20. Volunteers completing a worm ditch. This photo is looking upslope and water is spilling out of the worm ditch in the foreground. When working in a wet area, the new flow paths are apparent immediately. (July 2015)

- Road work and plug and pond structures were constructed with heavy equipment by Stream Dynamics in July and August 2015. Twenty-six plug and pond structures were built in Valle Seco in 2015. Road work was completed at six sites along Roads VC06 and VC08 (the roads along Sulphur Creek and Valle Seco). The purpose of the road work was to improve access to Valle Seco for equipment and volunteer vehicles and improve drainage to benefit wetlands. Rolling dips were installed at two of the road work locations. A rolling dip is self-cleaning and moves water off the road surface without facilitating wetland

erosion either upstream or downstream. It has gentle approaches that allow vehicles to navigate easily.

- A second volunteer weekend workshop was conducted by Los Amigos de Valles Caldera and Albuquerque Wildlife Federation on August 14-15, 2015. Thirty-eight volunteers attended the workshop. Volunteers were separated into three teams that went to different areas in Valle Seco build structures that support the expansion of wetlands. Team 1 went to the head of Tributary 1 and placed cobbles, sod and logs into small incised channels and headcuts in order to raise the water table and spread water across the narrow valley. This area was within the Thompson Ridge Fire burn area. Team 1 also felled dead (scorched) trees perpendicular to slope to catch sediment and debris that could be generated from future post-fire runoff and salvage timber harvesting. Team 2 dug worm ditches at the lower end of Tributary 1. Team 3 built Zuni bowls and one rock dams to arrest headcuts along main stem of Sulphur Creek.

Figure 21. Scott Compton, VCNP Natura Resource felling dead trees to use in restoration structures (August 2015).

Figure 22. Volunteers stuffing a felled tree into a channel in the burn area at the headwaters of Tributary 1. The tree plugs the channel and causes flow to spill out onto the wetlands (August 2015).

Figure 23. Volunteers digging a worm ditch (left) and carrying sod to plug channels (right) (August 2015).

Figure 24. Worm ditch completed by volunteers as it began to spread water across the valley (August 2015).

Figure 25. Volunteers building Zuni bowls to prevent headcuts from advancing upstream (August 2015).

- A third volunteer weekend workshop was conducted by Los Amigos de Valles Caldera and Albuquerque Wildlife Federation on June 17-19, 2016. Forty-eight volunteers attended the workshop. Volunteers worked in Tributary 5 of Valle Seco to build restoration structures, including: media lunas, one rock dams, worm ditches and sod dams. Sod was transplanted in bare areas where plug and pond structures had been built by machine. A boy scout troop from Albuquerque participated, and their primary contribution was to build an elk exclosure fence to protect a unique stand of Bebb's willows in a slope wetland in upper Tributary 5.

Figure 26. Volunteers digging a worm ditch to spread water in Valle Seco (June 2016).

Figure 27. A young volunteer carrying rocks to help build structures in Valle Seco (June 2016).

Figure 28. Volunteers transplanting sod to vegetate the perimeter of a plug and pond structure (June 2016).

Figure 29. A completed media luna will spread surface water to rewet historic wetlands. Looking upstream in Valle Seco (June 2016).

Figure 30. Boy scouts constructing elk exclosure fencing to protect old Bebb's Willows (June 2016).

Figure 31. Entire stand of Bebb's Willows showing boy scouts working on the fence (June 2016).

- In August and September 2016, Keystone Restoration Ecology built plug and pond structures in Tributaries 1, 2, and 4 of Valle Seco and along the mainstem of Sulphur Creek. Road work was completed using machinery at several sites in August and September 2016. Zuni bowls were constructed along Road VC08 to collect and infiltrate runoff from the road. The rocks for the Zuni bowls and structures built by volunteers were gathered by machine and by hand along Road VC06, then the area was re-graded to improve vehicle travel and runoff.

Figure 32. Road work included this machine-built Zuni bowl that collects runoff from Road VC08 (September 2016).

Figure 33. Machine construction of a plug and pond structure (August 2016).

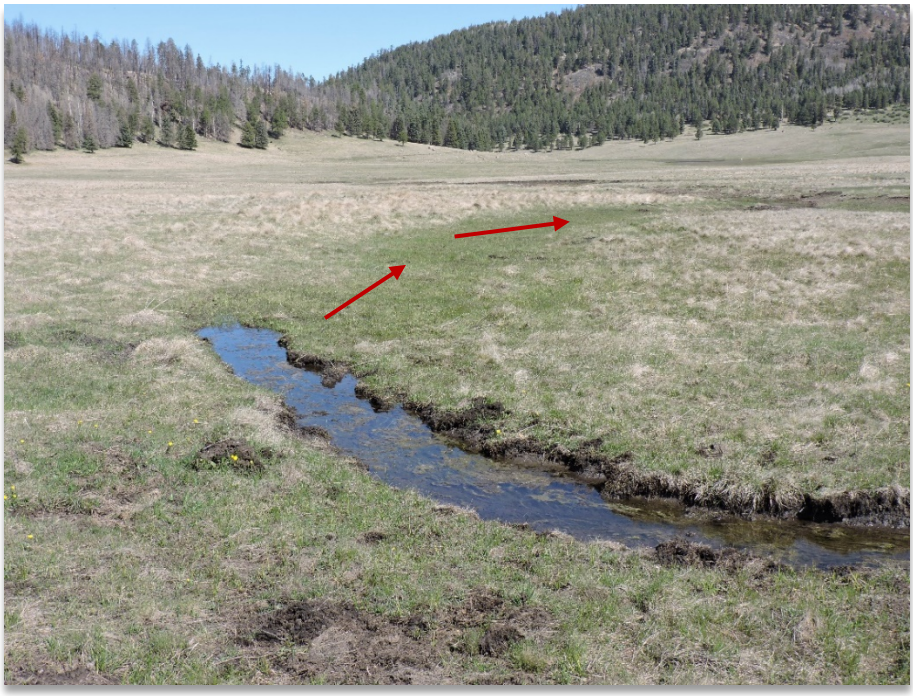

Figure 34. A contour swale that was constructed in Summer 2015 in conjunction with a plug and pond structure to re-route flow out of an incised channel at Site 37. Precipitation filled the swale and it is re-wetting the area downslope (September 2016).

- Vegetation monitoring was conducted in August 2016 and temperature data loggers were removed for the season in September 2016.

- A fourth volunteer weekend workshop was conducted by Los Amigos de Valles Caldera and Albuquerque Wildlife Federation on July 22-24, 2016. Forty volunteers attended the workshop. Participants built eleven rock structures including one rock dams to raise the water table within the wetlands and Zuni bowls to prevent headcuts from advancing. Volunteers also completed the elk exclosure fence that had been started at the June 2016 workshop.

Figure 35. Participants at the July 2016 Sulphur Creek Restoration Work Weekend

Figure 36. Volunteers building a one-rock dam to raise the water table along Sulphur Creek (July 2016).

Figure 37. Volunteers carrying boulders to build one-rock dams and Zuni bowls (July 2016).

Figure 38. Volunteers building a Zuni bowl to arrest a headcut in the wetlands along Sulphur Creek (July 2016).

- The WPO attended a four-day Stream Assessment and Stability Workshop titled *Inventory and Assessment of Stream Channels in the Arid Southwest*. The workshop was taught by Natural Channel Design, Inc. on October 17-21, 2016 in Flagstaff, AZ. Materials covered included a review of the Rosgen channel classification system, including hydraulic geometry, channel pattern and profile and hydrology. New materials covered included stream stability assessment methods: the BANCS model using the Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS); Pfankuch; SVAP-2; vegetation; channel evolution; and bar sampling. Also covered were: modeling (FlowSed and PowerSed) and

stream stability monitoring techniques (bank pins, scour chains, monumented cross sections and monitoring protocols). In addition to classroom lectures, the students spent 1.5 days in the field conducting stream stability measurements on creeks south of Flagstaff and several hours in the classroom processing and interpreting the data. Information obtained in the workshop will be helpful for continuing to develop the NMED Wetlands Program. Specifically, it is useful for evaluating stream channels and developing projects for wetlands protection and restoration.

- The contract between NMED and Los Amigos de Vales Caldera expired October 31, 2016 and the WPO was unable to extend it because of prohibitive language in the contract template. Instead, the WPO initiated a request for quotes procurement to re-establish a contract with Los Amigos de Valles Caldera to complete remaining project tasks. The new contract was executed on March 4, 2017.

- An updated QAPP was submitted in January 2017 and was approved by EPA on March 17, 2017 (QTRAK #17-208).

- Los Amigos de Valles Caldera hosted an all-day field trip to Sulphur Creek on July 6, 2017. The field trip included 21 participants from federal and state agencies, profit and non-profit organizations, and the Board of Directors of Los Amigos de Valles Caldera. Bill Zeedyk explained the design, construction, form and function of plug and pond structures and ancillary structures.

- A fifth volunteer weekend workshop was conducted by Los Amigos de Valles Caldera and Albuquerque Wildlife Federation on August 11-13, 2017. Thirty-nine volunteers attended the workshop. Participants built 13 ancillary rock structures along Sulphur Creek. Notable participants included hydrologists from Coconino National Forest in AZ and Lincoln National Forest in Southern NM, and Wildlands Restoration Volunteers in CO, who are all interested in implementing innovative wetland restoration methods.

- Final post-implementation monitoring was completed in September 2017, including wetland delineation, vegetation monitoring, temperature data loggers, and repeat photography.

Figure 39. Volunteers building a one rock dam to raise the water table and capture sediment along Sulphur Creek (August 2017).

- On October 30, 2017, Los Amigos de Valles Caldera submitted the Plug and Pond Technical Guide *The Plug and Pond Treatment: Restoring Sheetflow to High Elevation Slope Wetlands in New Mexico*, by Bill Zeedyk and Steve Vrooman. Tamara Gadzia provided design, layout and editing services. This guide describes and illustrates the plug and pond treatment method, including design and construction techniques, anticipated results and actual results. Many photographs are included of the work in Valles Seco as well as prior wetland plug and pond projects along San Antonio Creek in Valles Caldera National Preserve. The guide is an important tool for spreading the word about the plug and pond treatment method.

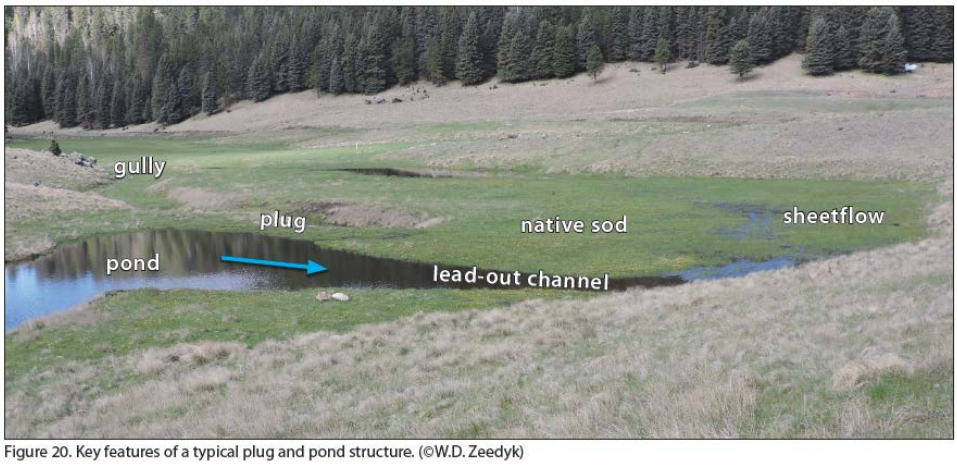

Figure 20. Key features of a typical plug and pond structure. (©W.D. Zeedyk)

Figure 40. Image from the Plug and Pond Technical Guide illustrating a plug and pond structure.

- On October 30, 2017, Los Amigos de Valles Caldera submitted a Sulphur Creek Monitoring Report and technical monitoring article *Vegetation and Hydrology Response to the Restoration of Tributary Wetlands in Valles Caldera National Preserve Using the Plug and Pond Method*, by Steve Vrooman, Kina Murphy, Jonathan Coop, and William Zeedyk. These documents rely on four lines of evidence to demonstrate project effectiveness. 1) Wetland delineation showed a 41.6 acre increase in wetland area; 2) temperature data loggers showed an increase in wetness downstream of the plug and pond structures as measured by wet versus dry days; 3) vegetation data indicate an increase in vegetation cover and wetland species downstream of the plug and pond structures; and 4) and repeat photography showed plug and pond structures holding water during the rainy season after construction.

- In December 2017, the Wetlands Program WPO completed the *Sulphur Creek Watershed WAP*. The WAP identifies wetland resources, threats and impairments, prior work, and a road map for future wetland work in the watershed including potential projects, stakeholders and funding sources.

List of Major Deliverables (on file at NMED)

Notes from Technical Steering Committee meetings

PQAPP

Project Design Elements

Clean Water Act 404 permit/401 certification

Monitoring Report

Semi-Annual Reports to EPA (including photographs of project progress)

Documentation of expenditures, including project match

The Plug and Pond Treatment: Restoring Sheetflow to High Elevation Slope Wetlands in New Mexico

Vegetation and Hydrology Response to the Restoration of Tributary Wetlands in Valles Caldera National Preserve Using the Plug and Pond Method.

Sulphur Creek Watershed Wetland Action Plan

Final Report

Lessons Learned

Ongoing communication between the Contractor (Los Amigos de Valles Caldera) land management agency (Valles Calder National Preserve – National Park Services), funding agency (NMED) and permitting agency (US ACE) was a key to success. An innovative project requires a collaborative team. Attention to detail is critical for all aspects of the project: from the permitting, field assessment, restoration implementation, planning of work weekends and field trips, to the completion of monitoring and reporting. The project must have reliable and knowledgeable contractors, subcontractors and agency contacts.

It is important to follow the rules and requirements established by the land management agency. For instance, in order to camp on Valles Caldera National Preserve (an opportunity that is not available to the public), volunteers had to park on the dirt road and walk their gear to their camp spots. Following the rules for a leave-no-trace campground helped gain the trust of land managers and support for future projects.

Inviting the land managers on field trip highlighting the project was also an effective method to gain their understanding and support.

Finally, it is best to build extra time into a project timeline because of unexpected delays by severe weather and/or natural disasters.

What Made the Project Successful

The project was successful due to many key partnerships developed among knowledgeable, committed and competent individuals and organizations. These partnerships strengthened the effectiveness of this project and future restoration projects.

- Valles Caldera National Preserve was a critical partner in the success of the project. Managers and staff were very involved and supportive of the restoration work, from completing necessary permitting requirements, to staging materials, to constructing the treatments along with the subcontractors and volunteers. Even when land management changed from Valles Caldera National Trust to the National Park Services, key staff remained the same (e.g. Park Superintendent, Natural Resource Supervisor). These staff remained committed to seeing the project completed. They assisted by: granting special use permits for research and restoration; allowing volunteers to camp along the road near the work site in Valle Seco; submitting CWA Act Section 404 permit applications and updates; contributing staff time for labor such as tree felling; employing their equipment such as a utility task vehicle for travel to the upper part of Valle Seco. Valles Caldera National Preserve also made the management decision to remove cattle from the Sulphur Creek watershed in 2016 to let the area rest. This has become a permanent management

decision, which will contribute greatly to the long-term success and sustainability of the project.

- Los Amigos de Valles Caldera is dedicated to it mission of supporting Valles Caldera National Preserve through outreach, education, restoration, and collaboration. Project managers demonstrated considerable persistence, diplomacy, and organizational skills in completing the project. Nina Wells continued to contribute labor to finalize the WAP after the contract with Los Amigos de Valles Caldera ended.
- Albuquerque Wildlife Federation has many hard-working volunteers who are knowledgeable about building restoration structures and consistently show up to work weekends. Many other volunteers contributed labor and mileage that resulted in the accrual of matching funds.
- Zeedyk Ecological Consulting, Keystone Restoration Ecology, Stream Dynamics, Tamara Gadzia, and Kina Murphy provided invaluable commitment, technical expertise, innovation and leadership to the project. Keystone Restoration Ecology contributed numerous hours of matching labor in the completion of project monitoring.
- The restoration design that was developed by Zeedyk Ecological Consulting and Keystone Restoration Ecology was successful because it was based on rigorous scientific assessment and the principles of natural channel design. Innovative techniques developed through the project will inform future restoration projects. Many of the techniques will be used to increase water storage in wetland soils to improve wetland condition, and to positively impact the local hydrologic cycle in degraded systems.
- Keystone Restoration Ecology contributed many hours of matching labor to complete monitoring on the other plug and pond structure in Valles Caldera National Preserve, so that comparative data could be included in the project deliverables.

What Made the Project Not So Successful

Although the project was very successful, there were several challenges and obstacles that had to be overcome.

1. The Thompson Ridge Fire in Summer 2013 inhibited access for several weeks during and after the fire. The Preserve's archaeologists were delayed in completing the survey that was required for cultural clearance. The Cajete Fire in Summer 2017 also closed the Preserve for a short duration, which had impacts on scheduling field work.
2. The transfer of land ownership from Valles Caldera National Trust to National Park Service caused some uncertainty and anxiety over whether approved restoration projects would move forward as planned, whether onsite camping would be allowed, and whether

ongoing land management decisions would be compatible with the restored wetlands along Sulphur Creek.

3. State of New Mexico procurement rules prevented extension of the contract Los Amigos de Valles Caldera. This resulted in a gap of several months during which the NMED Wetlands Program did not have a contractor. The WPO had to conduct a second procurement to hire the same contractor to complete the project.
4. The contractor project manager resigned when there were major deliverables pending with only a few months left on the contract. The WPO and the new contract project manager scrambled to ensure completion of deliverables.

Technical Transfer

- Two hundred forty-five copies of the Plug and Pond Wetlands Technical Guide were printed and distributed at wetlands roundtables, technical meetings, and upon request. The guide had been distributed to restoration practitioners, watershed groups, conservation organizations, government agencies (local, state, federal and tribal), and private landowners in New Mexico, Colorado, Texas, Montana and Oregon.

- Public availability of the guide ensures that the information is being disseminated in wetland restoration practitioner circles as well as to the interested public. The technical guide is available for download at: https://www.env.nm.gov/wp-content/uploads/2018/01/Valle_Seco_Plug_and_Pond.pdf

- 147 people volunteered their labor to build restoration structures, at the same time learning about the ecological functions of slope wetlands, stressors that damage wetlands, and ways to fix the damage.

- Twenty-one people attended a July 2017 field trip to learn about the plug and pond technique. The field trip included participants from federal and state agencies, profit and non-profit organizations, and the Board of Directors for Los Amigos de Valles Caldera.

- The Pine Cone newsletter of Los Amigos de Valles Caldera included five separate articles describing the wetlands restoration work weekends.

- The *Sulphur Creek Watershed Wetlands Action Plan* will be available for download at: https://www.env.nm.gov/surface-water-quality/wetlands/WAP/index.html. The WAP will be distributed to key stakeholders for restoration planning and fundraising. Key

stakeholders who currently can implement the WAP include: National Park Service – Valles Caldera National Preserve, Los Amigos de Valles Caldera, Albuquerque Wildlife Federation, WildEarth Guardians, Elk Valley Subdivision, and Defenders of Wildlife.

- Steve Vrooman made two presentations about project monitoring at the annual 2016 and 2017 Jemez CFLRP All-Hands meetings. More than 100 people attended each meeting.

- The project was featured at two Northern NM Roundtables. On November 14, 2016, Bill Zeedyk, Steve Vrooman and Nina Wells gave a presentation about all of their wetland restoration projects in Valles Caldera National Preserve. On January 18, 2018, Bill Zeedyk presented about the Plug and Pond Technical Guide. The attendance of the January 2018 roundtable by 91 people is indicative of keen interest in the plug and pond method.

- The monitoring technical article *Vegetation and Hydrology Response to the Restoration of Tributary Wetlands in Valles Caldera National Preserve Using the Plug and Pond Method* will be submitted to a peer-reviewed journal for publication.

Future Activity Recommendations

The *Sulphur Creek Watershed Wetlands Action Plan* was developed to prioritize future activities and recommendations for restoration. It is recommended that the actions identified in the plan be supported to further protect and restore wetlands in the watershed.

Restoration of slope wetlands through this project in the Sulphur Creek watershed is expected to be sufficient for natural processes to support wetland functions going forward. However, ongoing monitoring and field maintenance will still be beneficial. Future volunteer workshops by Los Amigos de Valles Caldera and Albuquerque Wildlife Federation should include having a small team check the restoration treatment structures and perform any small repairs that are needed. The Valle Caldera National Preserve and Los Amigos de Valles Caldera will be important partners in identifying and addressing upcoming issues.

The NMED Wetlands Program and Los Amigos de Valles Caldera will continue to promote the techniques developed in this project for use in other watersheds by giving presentations and disseminating the Plug and Pond Technical Guide. Areas where additional slope wetland restoration are expected to occur soon include the Rio Tusas, Rio San Antonio, Rio Fernando de Taos, and tributaries to Comanche Creek.

The NMED Wetlands Program will develop a Slope Wetlands New Mexico Rapid Assessment Method (NMRAM) through a separate Wetlands Program Development Grant. Information gained in this Sulphur Creek project may assist with developing assessment criteria for a Slope Wetlands NMRAM.