CN R924060

Zuni Bowl and One Rock Check Dam Research – Phase 1

Final Report

December 2024

Prepared by

Rio Grande Return for the New Mexico Department of Transportation Research Bureau

ACKNOWLEDGEMENTS: Thank you to several individuals and organizations for their assistance in locating Zuni Bowl and One Rock Dam structures and providing technical information, including Hamish Thomson and Peter Callen, Albuquerque Wildlife Federation; Melissa Houser, Santa Fe Conservation Trust; Jan-Willem Jansens and Adrienne Rosenberg, Ecotone Landscape Planning; Aaron Kauffman, Southwest Urban Hydrology, Morika Hensley, Santa Fe Watershed Association, and Bill Zeedyk.

FUNDING: This project was funded by the NM Department of Transportation Research Bureau.

CITATION: Weber, C. and K. Menetrey, 2024, CN R924060 Zuni Bowl and One Rock Check Dam Research – Phase 1 Final Report, prepared by Rio Grande Return for NM DOT Research Bureau, Albuquerque, NM.

COVER PHOTO: Zuni Bowl at Santa Rosa Creek in Valles Caldera National Preserve. Photo by Rio Grande Return, 2024. Santa Rosa #7, Object ID 77 in survey. Location: -106.5040297, 35.93222283. Photo looking upslope.

EXECUTIVE SUMMARY

Introduction

The Zuni Bowl and One Rock Check Dam Research Project, commissioned by the New Mexico Department of Transportation (NMDOT) and conducted by Rio Grande Return, investigates the effectiveness of Zuni Bowl and One Rock Dam structures as erosion control solutions for drainage issues affecting roadway infrastructure. This Phase 1A study aims to evaluate their feasibility, performance, and long-term viability within NMDOT-managed areas.

Background

Erosion and sedimentation from roadway runoff and culvert crossings pose significant challenges to infrastructure maintenance and ecological integrity. The Zuni Bowl and One Rock Dam, developed by Bill Zeedyk and inspired by traditional techniques of the Zuni Pueblo, offer low-cost, low-impact solutions for managing headcuts and channel erosion. This report seeks to address the following concerns:

- Lack of hydraulic testing for energy dissipators.
- Undefined installation and maintenance standards.
- Uncertain performance in controlling sediment and erosion over time.
- Integration into NMDOT’s asset management and culvert inventory systems.

Methodology

The project surveyed 97 erosion control structures across 11 sites in New Mexico, including public and private lands. Data collection included structural condition, erosion patterns, sediment capture, vegetation recruitment, and material use. Additionally, a workshop provided NMDOT staff with practical training in constructing and evaluating Zuni Bowls and One Rock Dams.

Key Findings

- Properly constructed Zuni Bowls dissipate energy effectively, while One Rock Dams slow water flow and promote sediment deposition.
- 68% of surveyed structures were fully intact and functioning as intended.
- Most surveyed structures exhibited no new erosion, indicating strong integration with their landscapes.

  - Sedimentation and vegetation metrics confirmed the structures' role in stabilizing channels and enhancing ecological function.
  - Structures built with local materials performed better, emphasizing the importance of using angular, appropriately sized rocks
  - 18% exemplary Zuni Bowl/One Rock Dam complexes were identified.
  - 58% of structures surveyed are located immediately downstream and adjacent to a roadway. 17% of structures surveyed are located immediately downstream and adjacent to NMDOT right-of-way.
  - The structures are suitable for small-scale headcuts and low-flow areas, with potential applications in roadway ditches and stormwater management.
  - Maintenance, site-specific design modifications, and ongoing monitoring are critical for sustained performance.
  - The workshop demonstrated the utility of hands-on learning for NMDOT staff, highlighting areas for improvement in design execution and maintenance planning.

Recommendations

- Develop hydraulic testing protocols and formalized design standards to improve installation consistency.
- Expand training opportunities and integrate these structures into NMDOT's Culvert Asset Management Program (CAMP) to address small levels of culvert outlet scour.
- Monitor and maintain structures post-installation, especially after significant storm events.
- Encourage collaborative efforts with non-profits and local communities to leverage resources and expertise.

This research underscores the potential of Zuni Bowl and One Rock Dam techniques to provide sustainable erosion control while promoting ecological restoration in New Mexico's unique landscapes. Further research and pilot projects are recommended to refine design standards and quantify long-term benefits.

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1. Introduction

NMDOT issued a contract with Rio Grande Return (RGR) to complete this investigation of the Zuni Bowl and One Rock Dam as erosion controls that could help address drainage from New Mexico roadway areas and adjacent lands. RGR is a 501 (3) non-profit organization that focuses on reviving the regenerative capacity of damaged ecosystems. RGR restores riverscapes and ecosystems unique to the arid Southwest using low tech process-based methods to foster resilience, adaptive capacity and stewardship in these important land and water resources. Diagrams of a Zuni Bowl and a One Rock Dam are shown in Figures 1-1 and 1-2, respectively.

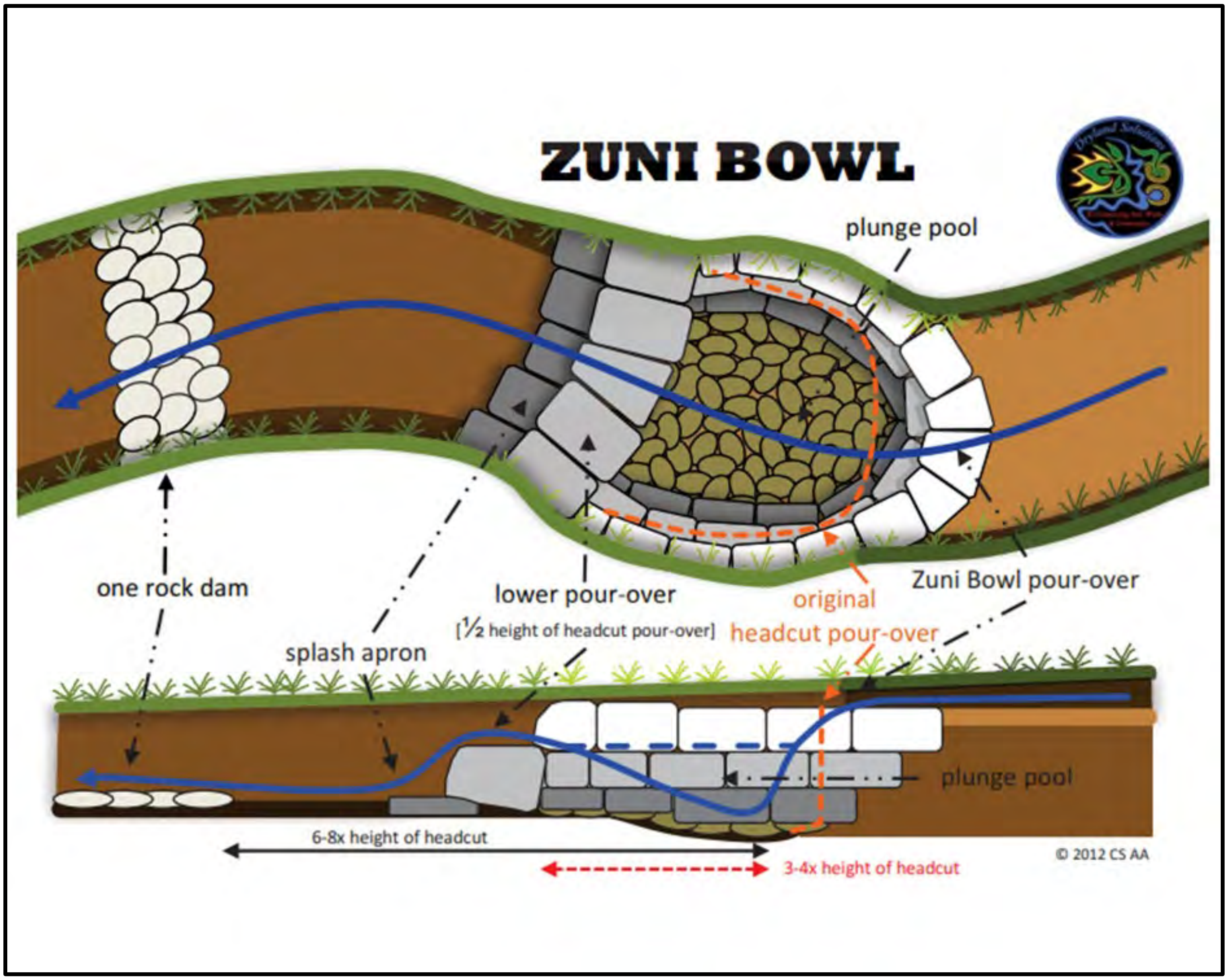

Figure 1-1. Schematic Diagram of a Zuni Bowl (Sponholtz and Anderson 2012).

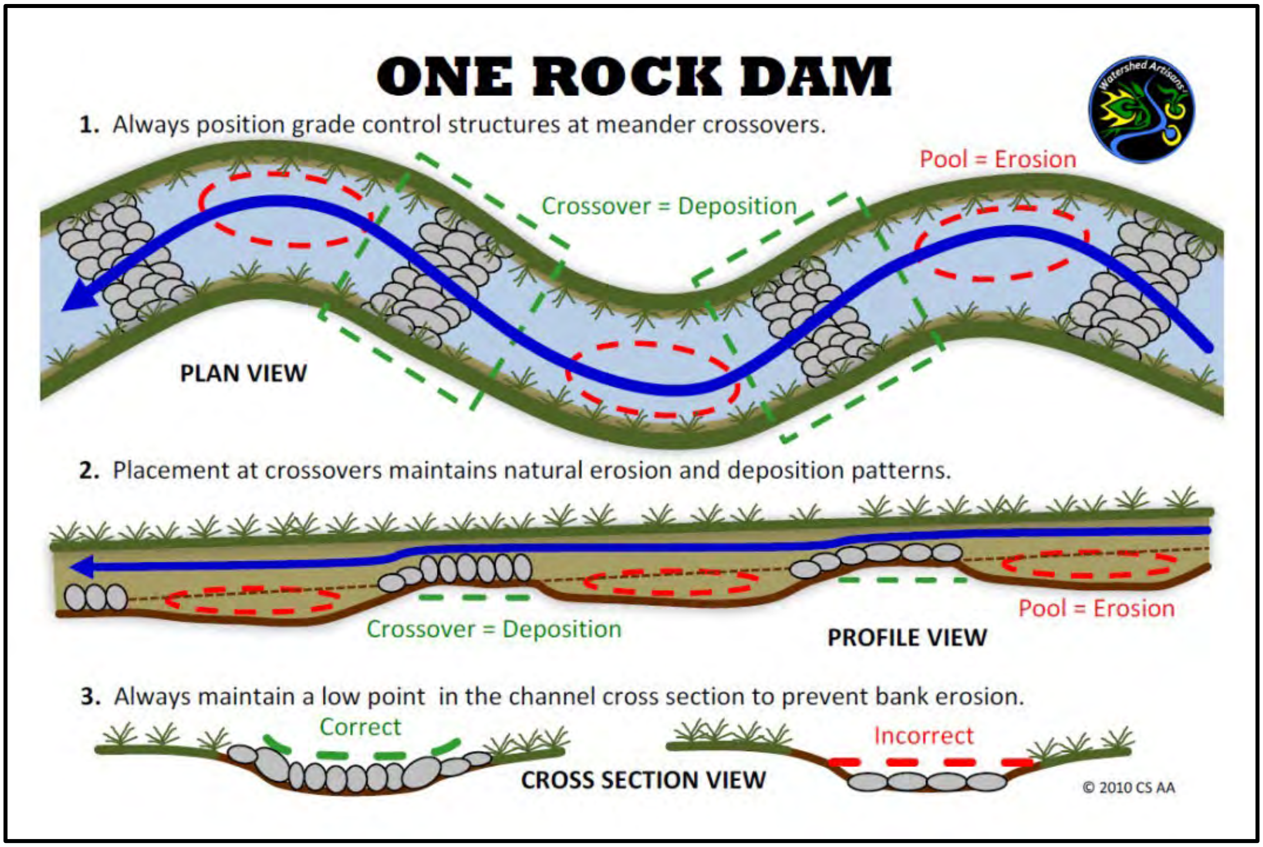

Figure 1-2. Schematic Diagram of a One Rock Dam (Sponholtz and Anderson 2012).

This study and final report aim to provide the information needed for NMDOT to address certain concerns about the applicability of the Zuni Bowl and One Rock Dam for headcuts including scour at small culverts, including:

- *Uncertainty for energy dissipators without hydraulic laboratory testing.*
- *Failure of controls related to lack of installation standards.*
- *Maintenance activities are not well understood.*
- *Are they sufficient sediment/erosion controls for roadway runoff or culvert crossings?*
- *Lifetime of controls / Asset Management*.

Hydraulic laboratory test results are needed to develop design equations and standards for the Zuni Bowl and One Rock Dam to be applied to erosion affecting NMDOT drainage structures. By inventorying and assessing a large sample size of these structures, this study provides the data needed to pursue hydraulic testing. This study also includes data on the record of failure and lifetime of the controls, locations that allow for watershed size to be calculated to determine if a given structure could be considered sufficient. This report summarizes our findings and includes resources for informing installation standards and maintenance activities.

Additional research phases are anticipated. Following hydraulic testing, design guidance validation will be needed and identified locations and complete descriptions of example occurrences of erosion in NMDOT Right-of-Way. Other phases may include HY-8 culvert model energy dissipater design option and NMDOT standard design language and details for the Zuni Bowl and One Rock Dam.

2. Background

2-1. History and Development of Zuni Bowl/One Rock Dam

General history of the terms

Ecological restoration in the arid American Southwest has long focused on the important ecological value of riparian zones. **Downcutting** is a result of channel erosion and results in bank erosion and loss of floodplain connectivity, leading to water quality impairments and increasing peak discharge (DNR Ecological Resources, 2010). Channel erosion is often caused by land use changes and vegetation loss. As human infrastructure has expanded across our region, in-channel structures such as dams, bridges and culverts have interrupted natural flow and watershed connectivity at large scales. In-channel modifications also lead to erosion far from the site of direct impact. A **headcut** is a knickpoint that develops due to the sudden increase in speed and erosive energy, especially when a channel is straightened, steepened, or there is reduced roughness of the streambed.

Definitions

aggradation: rising streambed, sedimentation

degradation: lowering streambed, erosion

discharge: volume of water carried by a stream per unit time

downcutting: downward channel erosion and loss of floodplain access

headcut: downcutting of streambed in upstream direction

hydrology: movement of water through the hydrologic cycle

knickpoint: sudden change in the slope of the streambed

sediment load: amount of sediment carried by a stream

velocity: speed of flow (feet per second, meters per second)

Techniques to address common forms of degradation in riparian zones (in perennial, intermittent and ephemeral waterways) have been adapted to other forms of channel erosion, including roadways and stormwater infrastructure. The **Zuni Bowl** and **One Rock Dam** are two erosion control structures defined and widely disseminated by Bill Zeedyk, a local restoration designer and educator who has been involved with the Albuquerque Wildlife Federation for 45 years. With Bill's guidance, Albuquerque Wildlife

Federation began building these structures in the late 1990's as cooperation developed across organizations offering hands-on learning opportunities on public lands.

The following descriptions draw heavily from Brad Lancaster's book *Rainwater Harvesting for Drylands and Beyond – Volume 2*.

The Zuni Bowl is a headcut treatment structure to halt the downcutting process (Lancaster, 2022). A well-placed Zuni Bowl will reduce velocity and resulting sediment load and increase soil moisture and resulting vegetation. Bill Zeedyk named and refined this structure after observing structures built by people of Zuni Pueblo who were implementing a project with Bill and who explained this was a common approach to arresting erosion in Zuni lands. It is a rock-lined plunge pool that dissipates the energy of falling water caused by a single waterfall at an eroding headcut. The upstream extent of the structure begins with an arc of rocks (upper pour over) that are locked in tightly with one another and set so the upper surface of the rocks is at the existing grade before the headcut begins. The angle of the headcut is laid back and all rocks lining the bowl are angled or battered into the slope. In a flood, water pours over the locked rock surface into a plunge pool and exits the raised spillway (lower pour over) onto a splash apron. The broader flow is maintained by the downstream One Rock Dam.

The One Rock Dam is a grade control structure placed perpendicular to the flow of water within a drainage to slow (not stop) the flow of water and increase the deposition of sediment. It is built one rock high from bank to bank so that water does not cut around the sides. There is no steep elevation drop on the downstream side of the One Rock Dam, but instead the streambed is protected from erosion of undermining by a splashpad of flat rocks set at the original bed elevation. This structure should be placed in the position where a riffle develops, in the shallower and straighter channel between meanders A One Rock Dam should increase the roughness of the channel bed, increase soil moisture and vegetation, and should gradually raise the bed elevation of the channel over time. One Rock Dams are the most common treatment for channelized and erosive situations. Each Zuni Bowl should be paired with a One Rock Dam downstream, placed in straight channel alignment, to protect the Zuni Bowl by decreasing the difference in grade between the top of the headcut and the downstream channel bed. One Rock Dams should be considered as part of a series or suite of structures; a singular One Rock Dam is not an appropriate scale of treatment for incision.

These structures are particularly relevant to NMDOT Right-of-Way management and protecting infrastructure as flood risk and damage increase due to a multitude of pressures. Right-of-Way is a strip of real estate that usually parallels at equal distances on both sides of the center lines of a highway, railroad, canal, or a utility. A fence usually indicates the approximate Right-of-Way line. The Zuni Bowl and One Rock Dam have a smaller footprint than the guides for rip rap basin in HEC-14 and are easier to permit through USACE 401/404 permitting because they are considered “soft” controls for channels. Other advantages include quicker project planning since controls can be installed without STIP justification, engineering stamp, and by NMDOT maintenance crews.

Culverts are narrower and smoother than the natural channel bed which causes flow velocities to increase within a culvert and a resulting surge of water flowing from the culvert, which can lead to outlet scour. In roadway projects, pipe and box culverts are most common. Especially near riparian areas, bottomless culverts are beneficial for wildlife passage and maintaining stream ecosystem processes. Bottomless culverts allow the passage of some woody debris (and so are at less risk of becoming clogged), generally cost less to maintain, and are unlikely to cause outlet scour.

Culverts managing stormwater (rather than stream crossings) must function at such wide ranges in velocity that outlet scour should be expected and addressed continuously, as reflected in NMDOT’s Culvert Asset and Management Program (CAMP). CAMP is a statewide initiative of the NMDOT Drainage Design Bureau to inventory and assess the location, size, and condition of NMDOT’s culvert assets.

The personnel and equipment needed to install a Zuni Bowl and One Rock Dam will vary by the scale of the headcut and the nature of the geology and base material. Working together, two people can construct a small Zuni Bowl and One Rock Dam in four hours with basic hand tools (at a minimum including: digging bar, spade, pick-mattock). At the larger end of the scale for headcuts at 3 feet tall and about 12 feet wide, without using equipment, two people using the same basic hand tools will need a full day at least. A team of four people is much more efficient for larger structures and allows someone to work on the One Rock Dam and others on the Zuni Bowl. If a large headcut is to be treated with boulders, consider using a tracked mini-excavator with thumb to place the Zuni Bowl Lower Pour-Over. Use the digging bar to adjust the boulder to the exact placement by hand after the mini-excavator has placed each boulder. Adjusting rocks by hand creates a much tighter fit than can usually be accomplished using a machine because small adjustments create more points of contact. Each rock placed should touch at least two but ideally three points against another rock. Most Zuni Bowl and One Rock Dam complexes can be completed in one day by two people with these basic hand tools. It is possible to safely move boulders – without heavy equipment – using cloth rock litters or by rolling, not carrying. Equipment is useful for getting rock to the work site, but is not necessary after that is done.

2-2. Implementation by Non-Profit Organizations

Bill Zeedyk was already involved with strengthening partnerships between land management agencies and community volunteer stewardship organizations like Albuquerque Wildlife Federation when he retired from the US Forest Service and began consulting in ecological restoration (as Zeedyk Ecological Consulting) and developing the structures described above. He developed designs for restoration that would include a strong role for volunteer workshops. This, in turn, lead to state and federal agencies expecting opportunities for the public to be part of new projects.

Each year Albuquerque Wildlife Federation hosts at least 12 workshops across the state attended by 15-75 people each (annually about 600 people). Until about 2017 almost all project sites were on public lands, usually providing volunteer match to increase the federal and state investment through grants (a requirement under federal laws since the 1980s). Each person's time under these grants is valued as skilled labor and often mileage is counted toward the total match, as well. This involvement has increased the investment in our watersheds and helped these many New Mexicans to better "read the landscape" and see where to help. Through the New Mexico Environment Department's Wetlands Program, many long-term and short-term investments have been directed to locally driven design and implementation that includes volunteers and non-profits.

As a state, we benefit now from this grassroots history and close partnership. Thousands of people have taken advantage of the many weekend workshops that organizations such as the Albuquerque Wildlife Federation and the Quivira Coalition offer. However, formal training opportunities for learning these approaches are difficult to find. Watershed Management Group in Tucson offers certification in rainwater harvesting, which includes learning to build Zuni Bowls and One Rock Dams. More opportunities for formal training are needed in New Mexico.

2-3. Adoption and Use by Agencies

The willingness to try new approaches is driven by curious individuals working within agencies that, as institutions, have low incentive to change practices. When Albuquerque Wildlife Federation began focusing on restoration opportunities in the 1980s and 1990s, many of the members were retired from the federal land management agencies and looked to the organization to continue their service to improving wildlife habitats. This allowed for personal connections and trust to increase as AWF sought to implement treatments on degraded public lands. Individual wildlife biologists, hydrologists, and others working within the agencies took personal interest in these approaches and did the required project management to permit the use of Zuni Bowls and One Rock Dams on public lands.

As more projects including these approaches were implemented and functioned as designed, there was an effort to generate broader understanding through official agency technical notes and guides. These are now available from the Natural Resources Conservation Service, NMED Surface Water Quality Bureau Wetlands Program, and US Forest Service.

Please see Appendix A: Reference List for a list of Zuni Bowl/One Rock Dam literature.

3. Zuni Bowl/One Rock Dam Survey

3-1. Identifying Locations

Zuni Bowl/One Rock Dam structures have been constructed at many locations in New Mexico. RGR conferred with and requested locational and photographic data from the following agencies and organizations that construct low tech process-based erosion control structures.

Government Agencies: New Mexico Environment Department Surface Water Quality Bureau, New Mexico Department of Game and Fish, US Fish and Wildlife Service, National Park Service, New Mexico Abandoned Mine Lands Program.

Non-Profit Organizations: Albuquerque Wildlife Federation, Quivira Coalition, Hermit's Peak Watershed Alliance, Rio Puerco Alliance, and Edwards Aquifer Authority Research and Data Center.

Businesses and Individuals: Ecotone Landscape Planning, Bill Zeedyk, MW Restoration Ecology, Southwest Urban Hydrology, Stream Dynamics, RiverSource, Stream Dynamics, High Desert Native Plants, Watershed Artisans Bat Conservation International, and RainCatcher, Inc.

Albuquerque Wildlife Federation provided the most extensive locational and photographic dataset through a series of project spreadsheets and catalogued photos. RGR relied on these data sets to locate and describe individual controls. RGR also reached out to the Valles Caldera National Preserve, Quivira Coalition and Rio Mora National Wildlife Refuge for access and approval to survey sites on properties that they manage.

Figure 3-1 shows the locations of structures surveyed, identified by structure type. Survey locations were chosen based on efficiency of time and travel. Sites within 3.5 hours of Albuquerque with multiple Zuni Bowls were prioritized. RGR staff have personal knowledge and experience at these sites and has gained additional information through outreach to the restoration community.

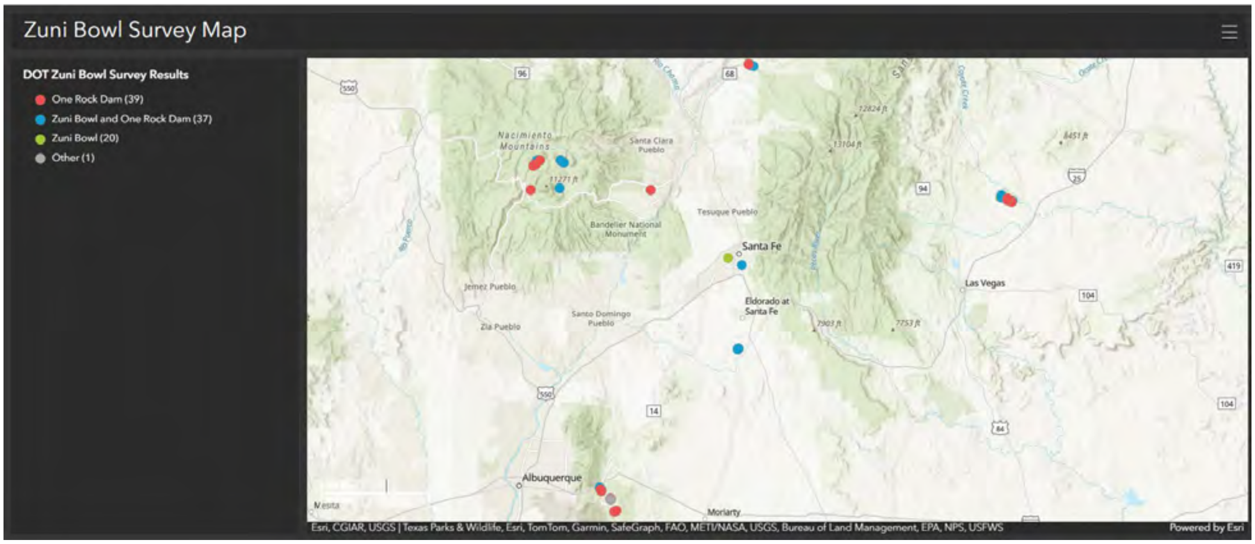

Figure 3-1. Map showing survey locations.

The following descriptions provide the basic history of restoration at the locations, as well as information on accessibility for future NMDOT research possibilities.

Santa Fe River and its tributary arroyos have been stabilized with many rock structures, including Zuni Bowls, plunge pools in series, and culvert drop structures where water enters the river, as well as cross vanes and bank armoring in the riverbed. The structures surveyed along the Santa Fe River were designed and built by Craig Sponholtz, Watershed Artisans, Inc. during approximately 2015-2018. The structures are located on City of Santa Fe property and are publicly accessible.

The Santa Fe Botanical Garden underwent extensive renovation during 2012-2014. Elaborate rock work was constructed including rain gardens to capture and infiltrate water, rock retaining walls, and numerous erosion control structures (e.g. Zuni Bowls, One Rock Dams, plunge pools, rock rundowns, and Media Lunas). Structures are visible inside the garden and along the arroyo that bisects the garden, between the parking lot and just downstream of the culvert that bisects Camino Corrales. The project was designed and constructed by Watershed Artisans, Inc. with labor assistance by The RainCatcher, Inc. and Southwest Hydrology, LLC. The structures that were surveyed in the arroyo are publicly accessible on City of Santa Fe property.

Cedro Creek is an ephemeral drainage in a limestone bedrock setting, located at the northern end of the Manzano Mountains just east of Albuquerque. The area is popular for recreation and has been impacted by runoff from Road 337. In approximately 2005, the New Mexico Environment Department funded an effort with Quivira Coalition and Bill Zeedyk to restore wetlands along Cedro Creek, as described in a Cedro Creek Wetlands Action Plan (NMED, 2009). Because of its proximity to Albuquerque and the availability of angular limestone building material, Cedro Creek became a long-term volunteer project for Albuquerque Wildlife Federation. Other restoration practitioners were involved in assessment and restoration design at various times, including Craig Sponholtz (Watershed Artisans, Inc.), Van Clothier (Stream Dynamics, Inc), and Steve Vrooman (Keystone Restoration Ecology). The age of rock structures built in Cedro Creek ranges from 2005 to present. Data from Albuquerque Wildlife Federation were used to date the structures for the survey. All of the structures surveyed are publicly accessible on land managed by Cibola National Forest.

<u>Rio Mora</u> is a perennial river that flows through Rio Mora National Wildlife Refuge located between Las Vegas and Wagon Mound, NM. The Quivira Coalition and Albuquerque Wildlife Federation began working on restoration of wetlands along the river and upland tributary arroyos in approximately 2008. Work was supervised by Bill Zeedyk with early involvement of Keystone Restoration Ecology and Steve Carson (Rangeland Hands). Most of the Zuni Bowls surveyed are in an upland setting at the heads of arroyos caused by wagon roads dating from the 19th century. The structures are built of the flagstone type sandstone found onsite. Data from Albuquerque Wildlife Federation were used to date structures. All structures surveyed are publicly accessible, but permission from the US Fish and Wildlife Service is required for access.

<u>Sulphur Creek</u> is a perennial headwater creek that originates in Valle Seco within the Valles Caldera National Preserve. The area is characterized by headwater slope wetlands that have developed incised channels from historic land uses (e.g. impacts of roads, livestock and wildlife grazing). From approximately 2015-2017, Albuquerque Wildlife Federation and Los Amigos de Valles Caldera undertook a restoration effort that was funded by the New Mexico Environment Department. See Sulphur Creek Wetlands Action Plan (Menetrey and Wells, 2017) and The Plug and Pond Treatment: Restoring Sheetflow to High Elevation Slope Wetlands in New Mexico A Restoration Project in the Valle Seco of the Valles Caldera National Preserve, Jemez Mountains (Zeedyk and Vrooman, 2017) for project descriptions and documentation of structure locations. Zeedyk Ecological Consulting supervised construction, and Keystone Restoration Ecology and Stream Dynamics constructed the machine-built structures. Volunteers constructed the hand-built structures. Structures were made with limestone gathered onsite or transported from a quarry. All structures surveyed are publicly accessible though backcountry permission from the National Park Service is required. RGR has a research permit for ongoing monitoring in Valles Caldera National Preserve.

<u>Redondo Creek</u> is a perennial headwater creek in Valles Calderas National Preserve. The area is characterized by slope wetlands that have been impacted by historic land use practices, including diversion of the creek to an irrigation channel. Beginning in 2011, WildEarth Guardians planted thousands of willows and constructed elk exclosure

fencing with funding from the New Mexico Environment Department. The purpose of the project was to create beaver habitat and reduce stream temperature through shading. RGR and Stream Dynamics, Inc. later received funding from the Rio Grande Water Fund to re-route the creek to it historic location and re-wet historic wetlands. This included the construction of many rock grade-control structures within the creek bed in 2020-2021. All structures surveyed are publicly accessible though backcountry permission from the National Park Service is required.

Santa Rosa Creek is an intermittent headwater tributary to San Antonio Creek in Valles Caldera National Preserve. It is characterized by slope wetlands bisected by a small creek that is channelized and incised. Wetland restoration work was funded by the New Mexico Environment Department. Albuquerque Wildlife Federation built erosion control structures. Work was designed by Zeedyk Ecological Consulting with machine work performed by Watershed Artisans, Inc. Structures were initially built in approximately 2010-2011, then more structures were built following the 2011 Las Conchas Wildfire and post-fire flooding. All structures surveyed are publicly accessible though backcountry permission from the National Park Service is required.

La Jara Creek is a perennial headwater spring-fed tributary to the East Fork Jemez River that flows across Valle Grande in Valles Caldera National Preserve. It is characterized by a steep stream reach that flows on a forested alluvial fan that empties on the shallow slopes of the Valle. Slope wetlands in the Valle Grande are channelized and somewhat incised. After the 2013 Thompson Ridge Fire, Los Amigos de Valles Caldera obtained funding from the New Mexico Environment Department to restore slope wetlands along La Jara Creek but spreading out water and capturing post-fire flooding sediment. Restoration occurred in 2018-2019, with rocks structures built by Albuquerque Wildlife Federation and Los Amigos de Valles Caldera, with supervision and machine-built structures by Keystone Restoration Ecology.

Galisteo Basin. Santa Fe Conservation Trust Galisteo property is adjacent to the larger Galisteo Basin Preserve open space near Lamy, NM. The property is characterized by sandstone outcrops in an upland setting dissected by ephemeral arroyos. Erosion control structures have been built by volunteers with Santa Fe Fat Tire Society and Santa Fe Conservation Trust in 2023. Jan-Willem Jansens (Ecotone Landscape Planning) designed and supervised construction of the structures that were surveyed. Santa Fe Conservation Trust manages their property with recreation, conservation and environmental education objectives. All of the structures surveyed are publicly accessible but special permission from Santa Fe Conservation Trust is required in order to drive to the structures behind locked gates.

Embudo Valley. Embudo Valley is located in Rio Arriba County. The area is characterized by highly erosive sandstone. Ephemeral arroyos drain to the Rio Embudo. Some of the arroyos have spring-fed perennial reaches. Ecotone Landscape planning has been working in the Embudo Watershed since at least 2010. The most recent restoration project, funded by the New Mexico Environment Department, is a collaboration among William J. Miller Engineers, San Isidro Permaculture, Wood Sharks, and the Embudo Valley Acequia Association. The structures surveyed were constructed in 2023 and are publicly accessible, but coordination with the NM State Land Office and US Bureau of Land Management is recommended.

3-2. Survey Design

RGR designed a survey in ESRI Survey 123 to assess the condition of Zuni Bowl/One Rock Dams. The survey includes categories for:

- Condition of the structure with respect to intactness of rocks.
- Reason for any degraded condition.
- Rock type.
- Rock angularity.
- Rock size.
- Structure dimensions for each structure and distance between Zuni Bowl and Rock Dam.
- Erosion around or within a structure.
- Sedimentation within a Zuni Bowl.
- Embeddedness of a One Rock Dam.

3-3. Survey Implementation

The Survey Team consisted of Abe Aufdermauer, Cameron Weber and Karen Menetrey. Although not all team members were present at each of the sites, the team developed, reviewed, pre-tested and refined the survey together to ensure understanding and for quality assurance.

Survey equipment included an Apple iPad (10^{th} Generation) loaded with the ArcGis Survey 123 app, an external Global Positioning System with Bluetooth connection, and 100 ft measuring tape graded to 10ths of a foot.

Ninety-seven structures were recorded in the survey at the 11 locations described in Chapter 2: Santa Fe River, Santa Fe Botanical Garden, Cedro Creek, Rio Mora, Sulphur Creek, Redondo Creek, Santa Rosa Creek, La Jara Creek, Galisteo Basin, Embudo Valley and White Rock.

3-4. Survey Results

Survey results are summarized in Appendix A, which lists all data in tabular format in an Excel file (.xlsx). Complete survey results are included in Appendix B, which provides a printout of all data collected including photographs. A shapefile of survey locations is also provided to NMDOT with this report.

RGR has published survey results and designated them as public files available to those who have an ArcGIS Online access: https://arcg.is/1nX0fP0

Below are a series of charts that summarize the survey results.

Table 3-1. Number and Type of Structures Surveyed.

Structure Type	**# Surveyed**
Zuni Bowl and One Rock Dam complex	37
Zuni Bowl	20
One Rock Dam	39
Other (Rock Culvert Protection)	1
Total	**97**

Structure Age

The age of the surveyed structures ranges from 2008 to 2024. This is shown in Figure 3-2. Age determinations were based on best available information from builders and professional knowledge of the surveyors. Age of the structure is unknown for 19 of the structures.

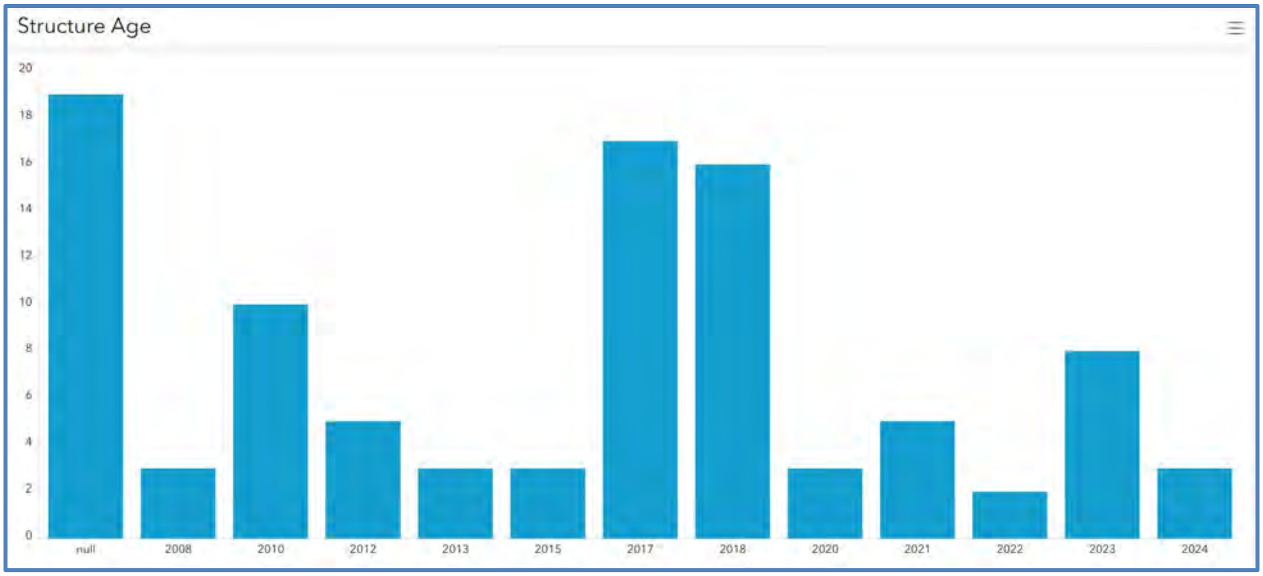

Figure 3-2. Structure Age (ranging from 2008 to 2024).

<u>Condition</u>

The majority of structures surveyed (68%) were entirely intact, whereas the remainder (32%) had at least one rock dislodged or broken. This is shown in Figure 3-3. This means that most of the structures have become integrated with the landscape and are likely functioning to arrest erosion. Dislodged rocks were deemed to be caused by water in all cases except one that was identified as human interference. RGR did not identify or survey any significantly deteriorated structures. Figure 3-4 shows a structure where some rocks were dislodged by water.

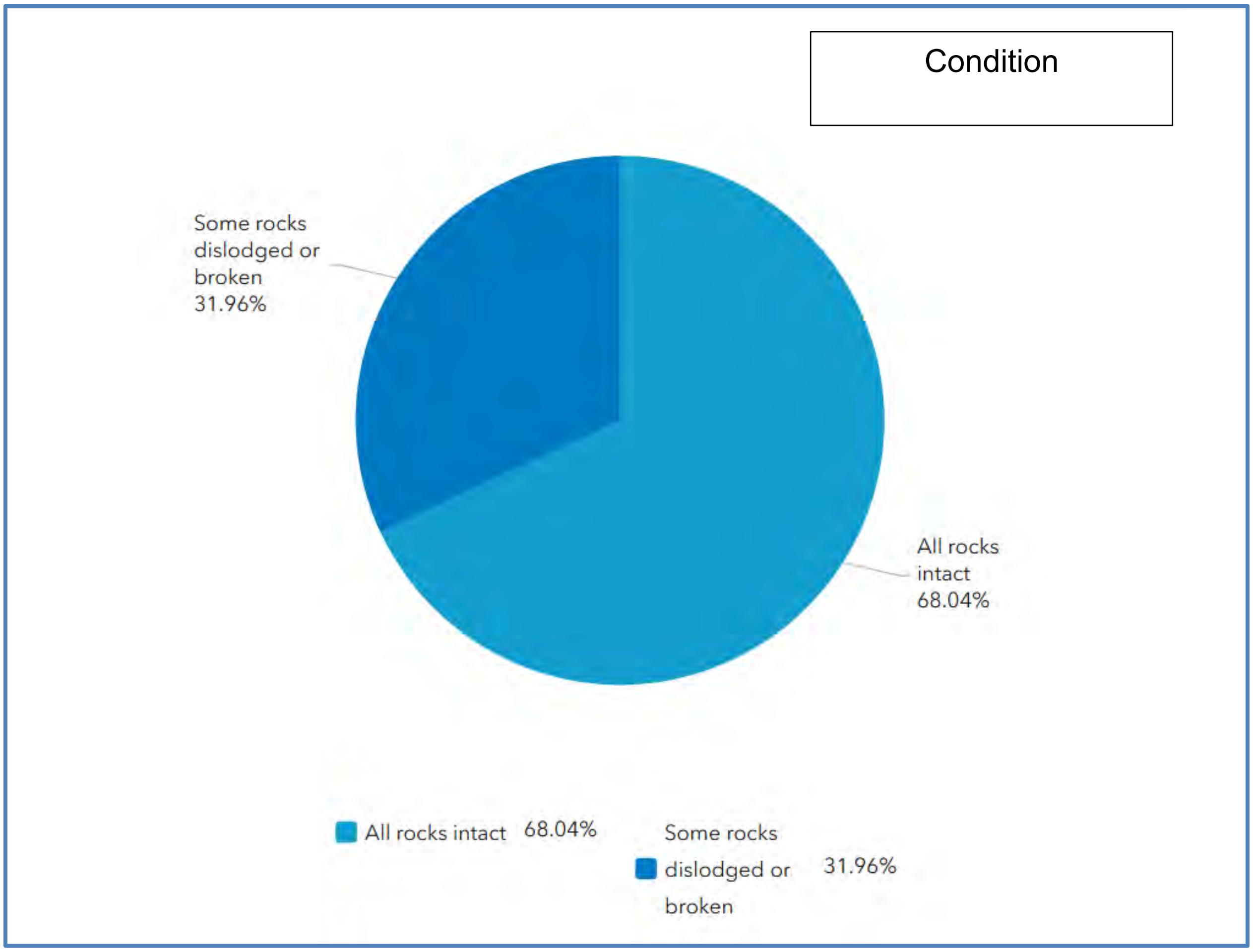

Figure 3-3. Condition (all rocks intact, some rocks dislodged or broken).

Figure 3-4. Example of some rocks dislodged or broken. Rocks were displaced from the Zuni Bowl Pour-Over shown in the center of the photo. Sulphur Creek #2. Object ID 51 in survey. Location: -106.6014258, 35.9241155. Photo looking upslope.

<u>Erosion</u>

The majority of the structures (75%) exhibited no new erosion. This is shown in Figure 3-5. Some structures experienced undercutting (or piping) around the rocks (14%). Fewer show signs of erosion around the sides of the structure (8%). At the remaining (3%) of survey points, erosion was observed between the Zuni Bowl and One Rock Dam due to steep slopes. Figure 3-6 shows an example of a structure where undercutting or piping has occurred.

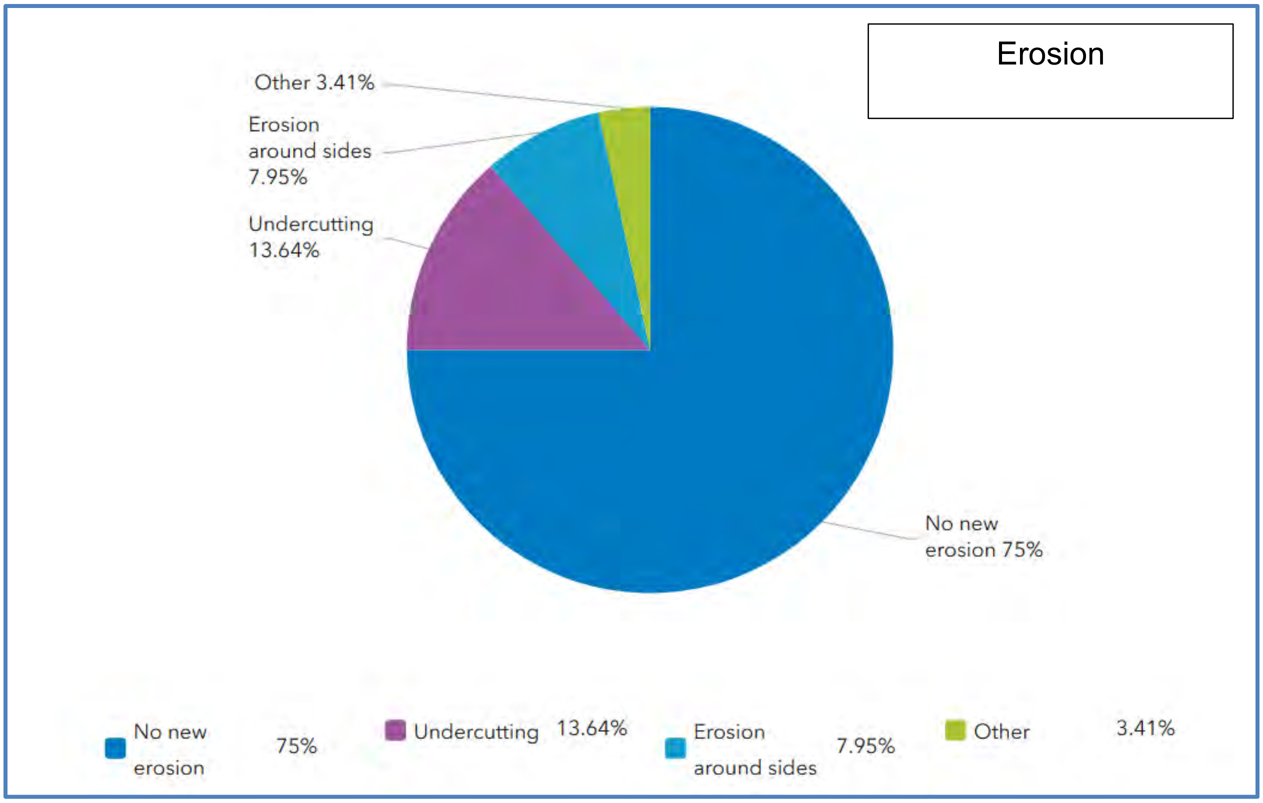

Figure 3-5. Erosion. (no new erosion, undercutting, erosion around sides, other).

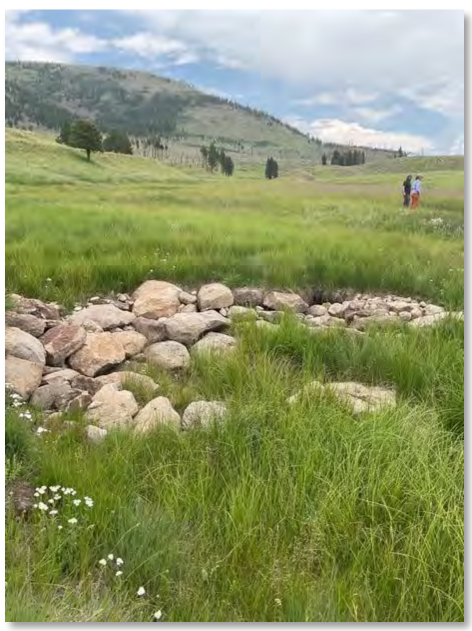

Figure 3-6. Undercutting or piping through the rocks is seen on the far side of the Zuni Bowl wall on the right. Santa Rosa #6, Object ID 55 in survey. Location: -106.5974051, 35.92597653. Looking toward valley left.

Construction Material

More than half of the structures surveyed were constructed with sedimentary rocks (55%). This is shown in Figure 3-7. Igneous rocks are the next most abundant (33%), and then metamorphic rocks (6%). Some structures had a mixture of rock types (6%). These data indicate that structures have been built successfully with a variety of rock types. Limestone was the most common rock type, likely because 1) the structures surveyed at Cedro Creek are all made from limestone gathered onsite, and 2) limestone is a common quarry rock that can be obtained in Northern New Mexico. Similarly, nearly all structures that were surveyed at Rio Mora were built with sandstone gathered on site. Building materials that are gathered onsite will be influenced by local geology.

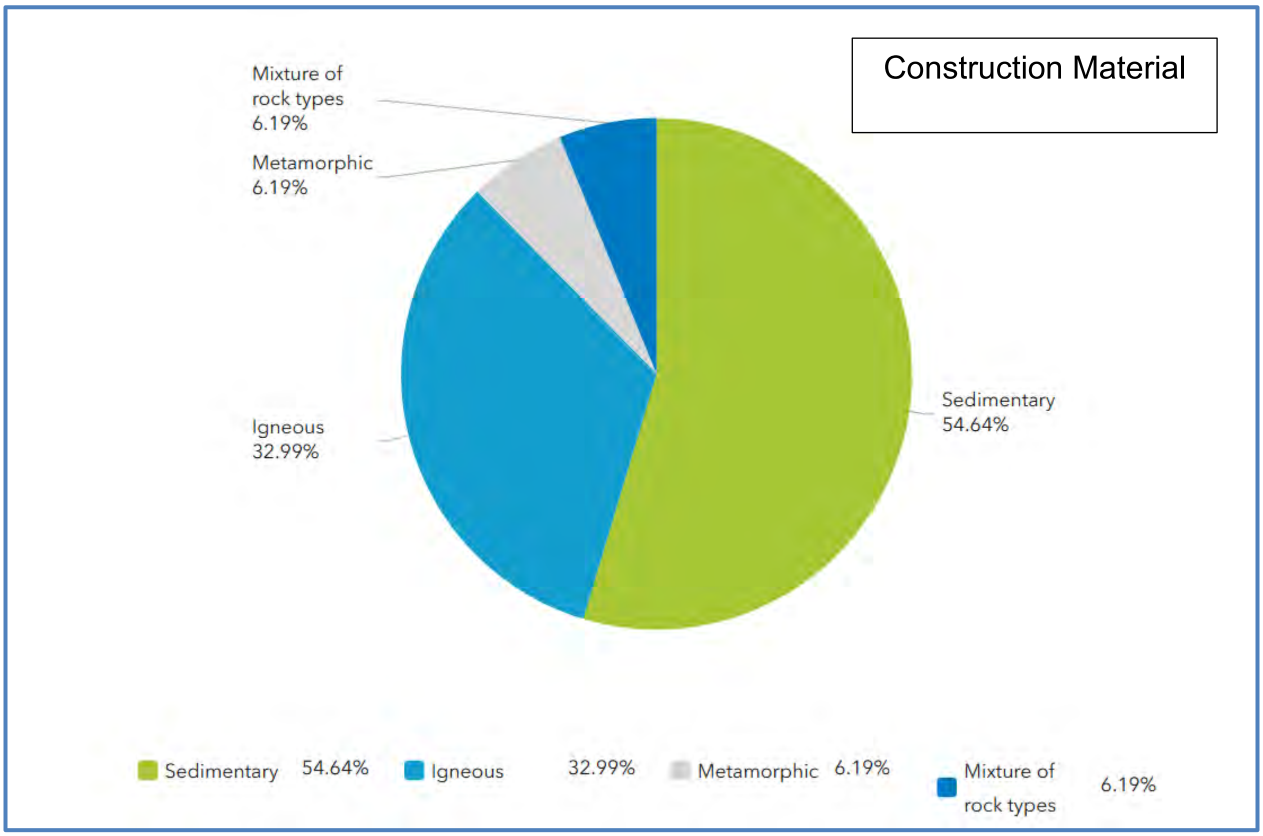

Figure 3-7. Construction Material (type of rock – sedimentary, igneous, metamorphic, mixture).

Angularity

The majority of the structures were built with angular (38%) or partially angular (44%) rocks. This is shown in Figure 3-8. A lesser portion have a mixture of rock with varying angularity (13%). Very few structures are made from round rocks. For the survey, angular means all the rock is all edges and flat surfaces corners and edges. Partially angular means some edges and flat surfaces. Round means all rounded. Using rocks that are partially angular to angular is desirable because these rocks will interlock and reduce pore space in the structure. Figure 3-9 shows examples of structures with different rock angularity.

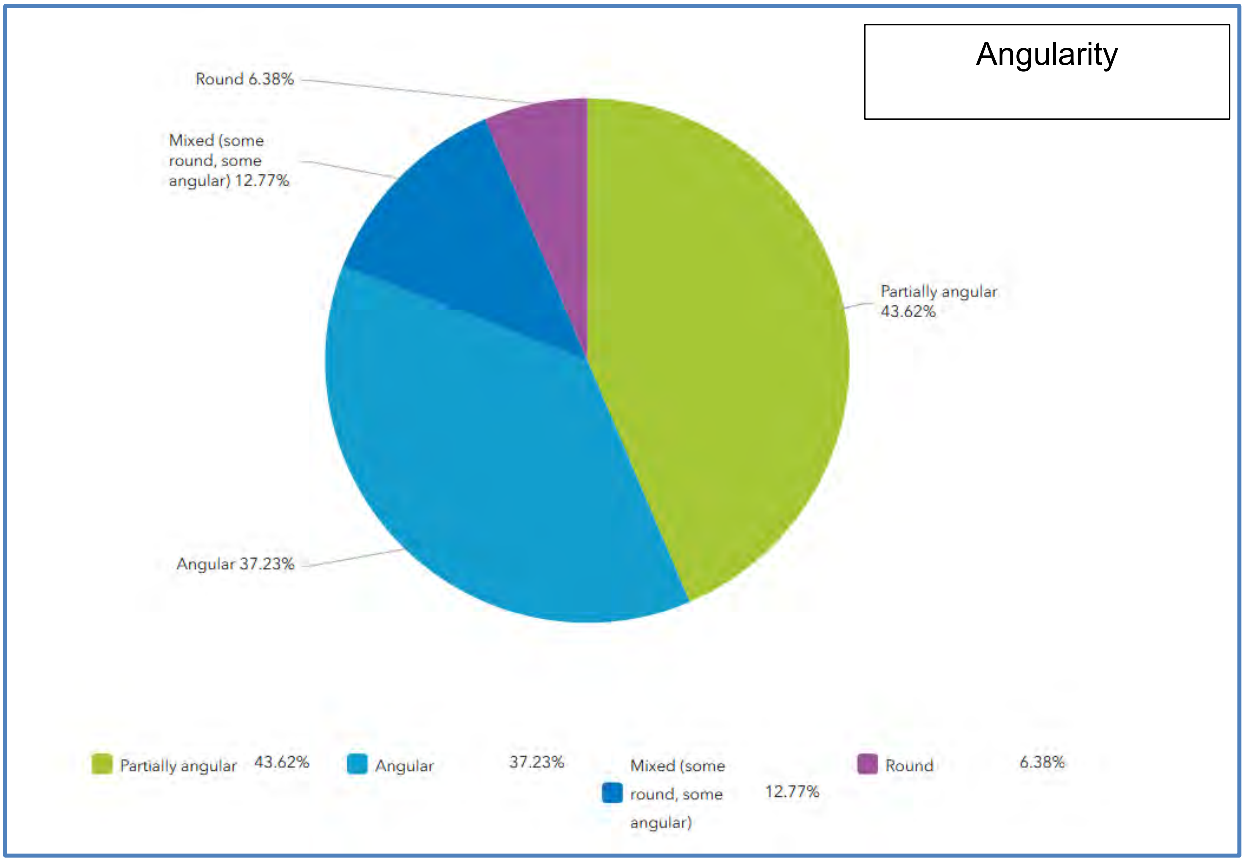

Figure 3-8. Angularity (angular, partially angular, round, mixed).

Figure 3-9. Examples of angular (left), partially angular (middle) and round (right) rocks. Locations: -106.3531756, 35.0482939; -106.5187878, 35.86520847; and -105.97 27933, 35.68119967, respectively.

Zuni Bowl Rock Size and One Rock Dam Rock Size

Rock size was surveyed based on the average rock size in the Zuni Bowl. Figure 3-10 shows the survey result for Zuni Bowl Rock Size. The smallest rock size category (6”-12”) is the most common (58%), and the larger rock sizes are less common: 13”-18” (17%), 19”-24” (9%), and 25”-36” (13%). This reflects the fact that most Zuni Bowls are hand-built and smaller rocks are more reasonable for people to move. The largest rock category observed is indicative of machine-built structures.

Similarly, One Rock Dams are almost always hand-built because there are no design criteria that require a rock size larger than people can move. Figure 3-11 shows the survey results for One Rock Dam Rock Size Seventy-six percent (76%) of the surveyed One Rock Dams had rocks in the 6”-12” category, twenty percent (20% had rocks in the 13”-18” category, and (4%) had rocks in the 19”-24” category.

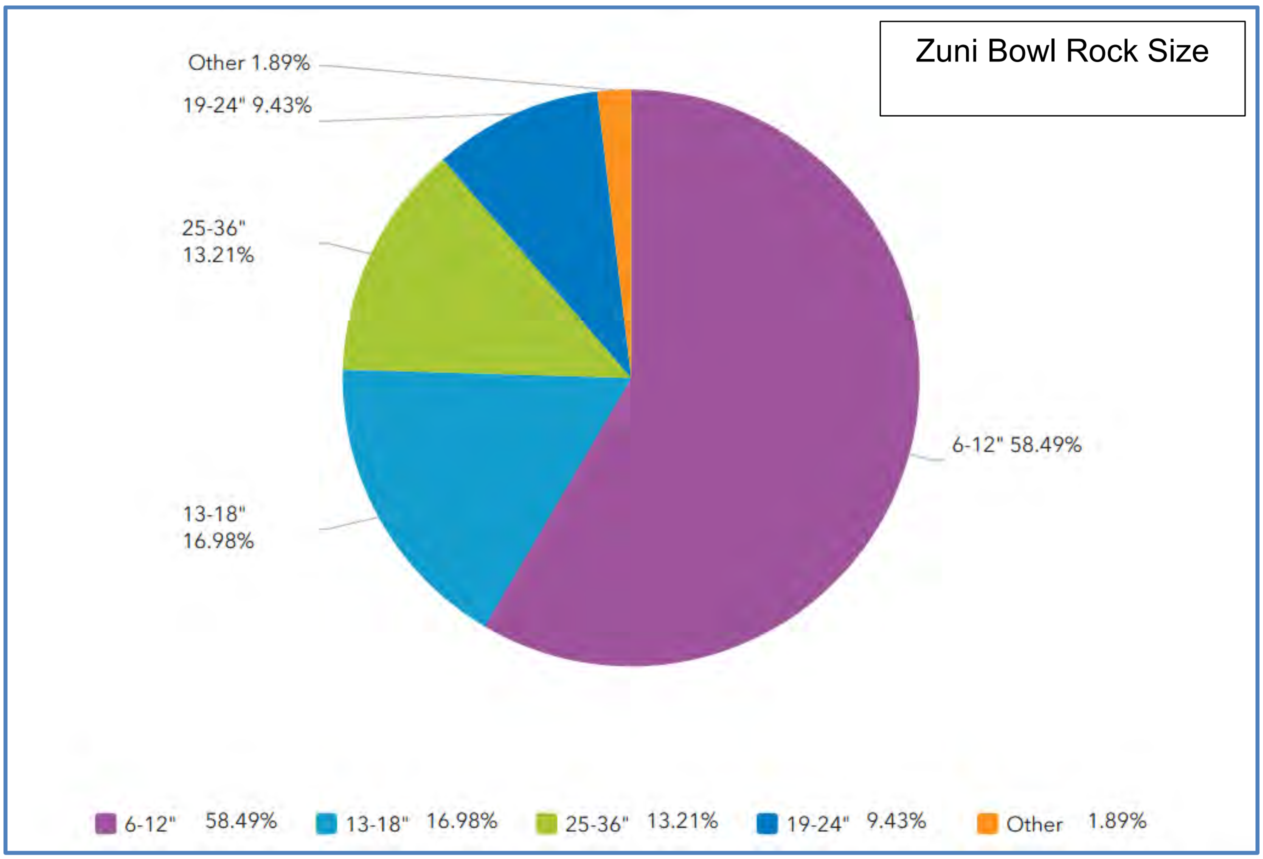

Figure 3-10. Zuni Bowl Rock Size (categories ranging between 6”-36”).

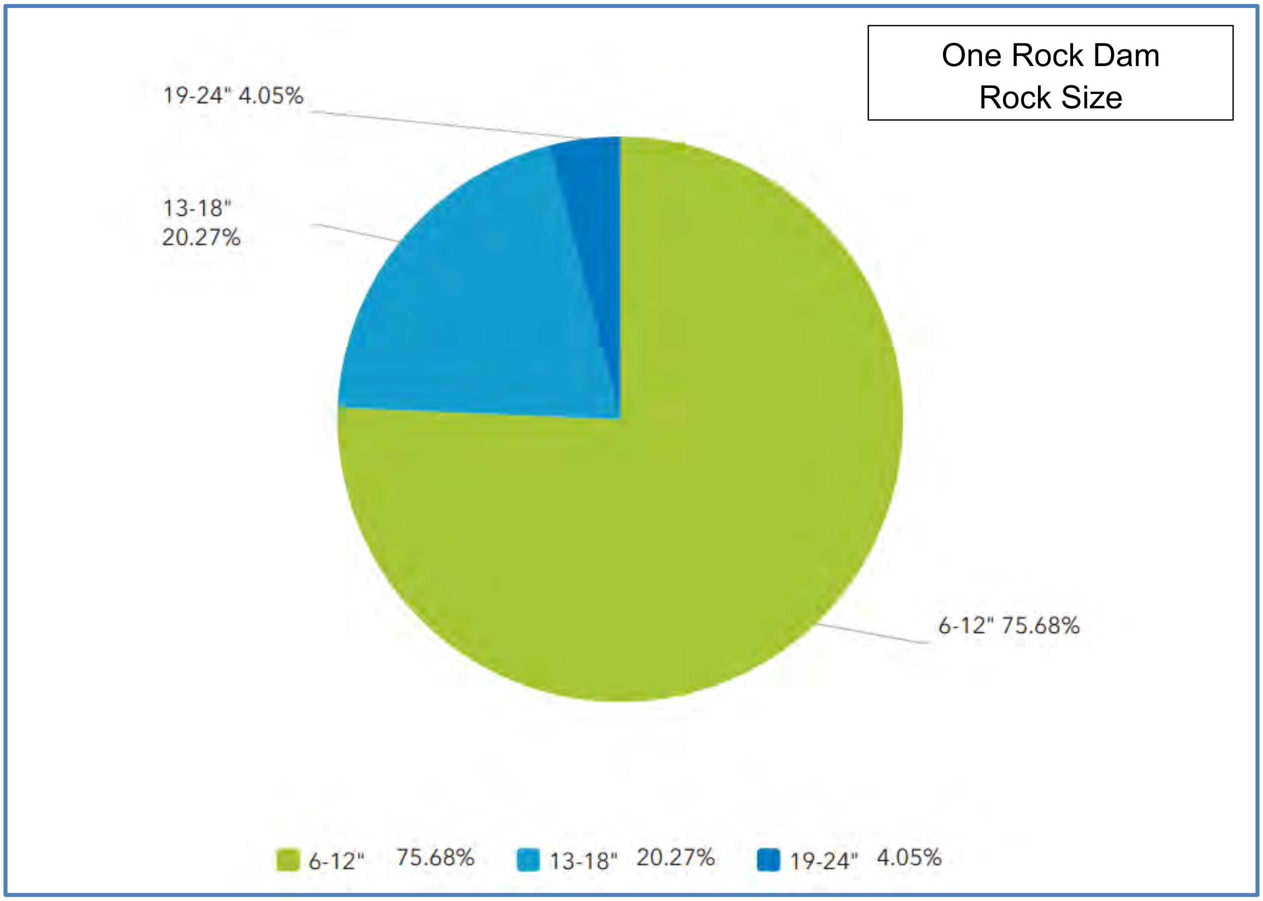

Figure 3-11. One Rock Dam Rock Size categories ranging between 6”-24”.

<u>Sedimentation and Embeddedness</u>

Zuni Bowls were surveyed for sedimentation to determine whether they have captured sediment. Results for Sedimentation are shown in Figure 3-12. Similarly, One Rock Dams were surveyed for embeddedness determine whether they have been incorporated into the landscape. Results for Embeddedness are shown in Figure 3-13.

For sedimentation, nearly half of the Zuni Bowls fell in the partially filled category, and for embeddedness, nearly three quarters fell in the One Rock Dam category.

Zuni Bowls are designed to fill with sediment and be flushed out in subsequent flow events. One Rock Dams are also designed to capture sediment and eventually be buried. Additional One Rock Dams can be added just upstream and overlapping existing dams in order to raise the grade.

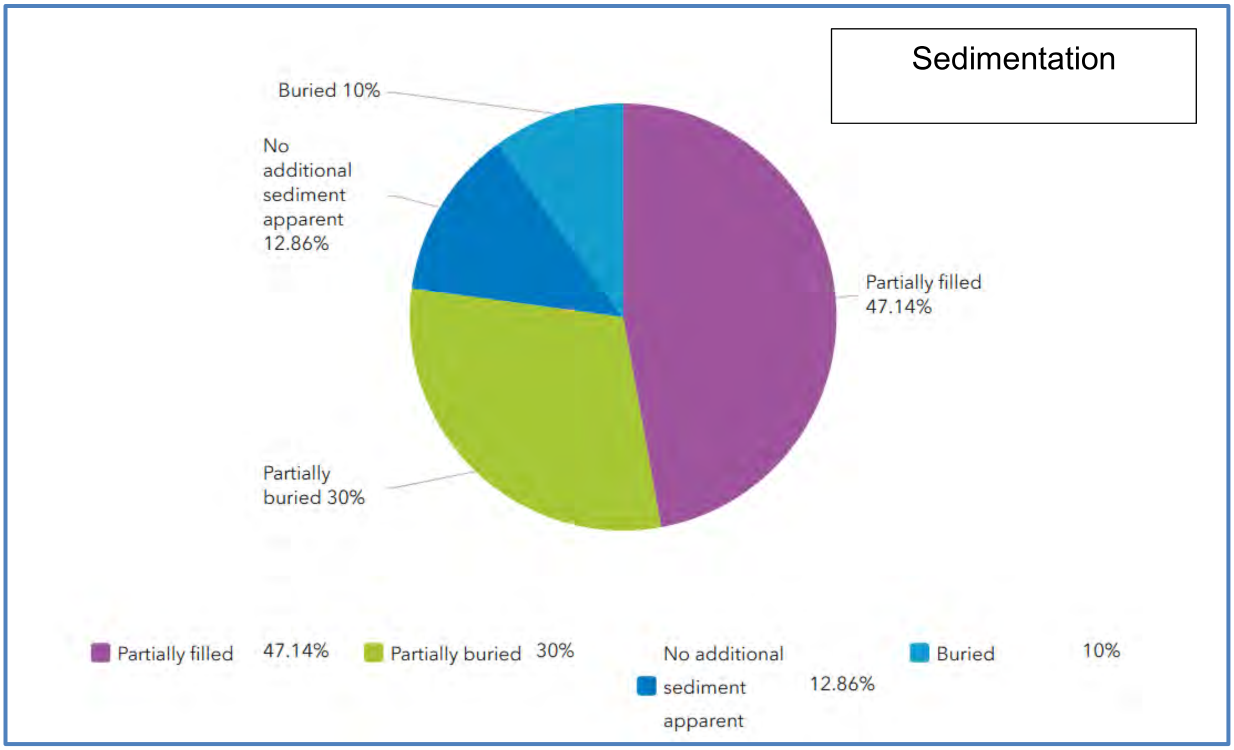

Figure 3-12. Sedimentation (buried, partially buried, partially filled, no additional sediment apparent)

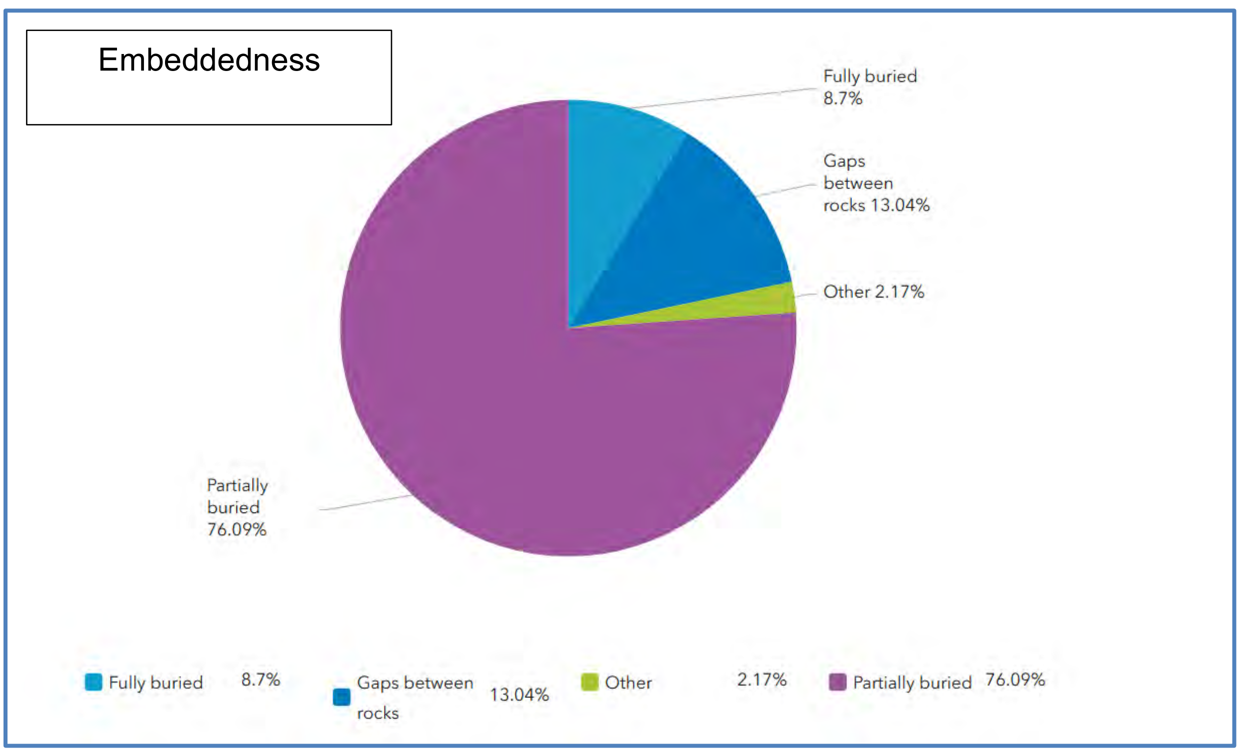

Figure 3-13. Embeddedness (fully buried, partially buried, gaps between rocks, other).

Vegetation

The structures exhibited a range of vegetation amounts and types of vegetation. The bimodal peaks shown in Figure 3-14 are likely indicative of the different ecosystems where the structures were surveyed. In upland settings the percentage of pore space within the structures that is occupied by vegetation ranged from bare to 50%. In wetland settings the space occupied by vegetation is 50%-100%. This metric was complicated by the fact that some of the Zuni Bowls in wetland settings are permanently or semi-permanently filled with water. Unless there were aquatic plants present this situation was not counted as vegetated. Examples of structures with different percentages of vegetation are shown in Figure 3-15. The type of vegetation was most likely in all structures to be grass or a mixture of grass and forbs, as shown in Figure 3-16.

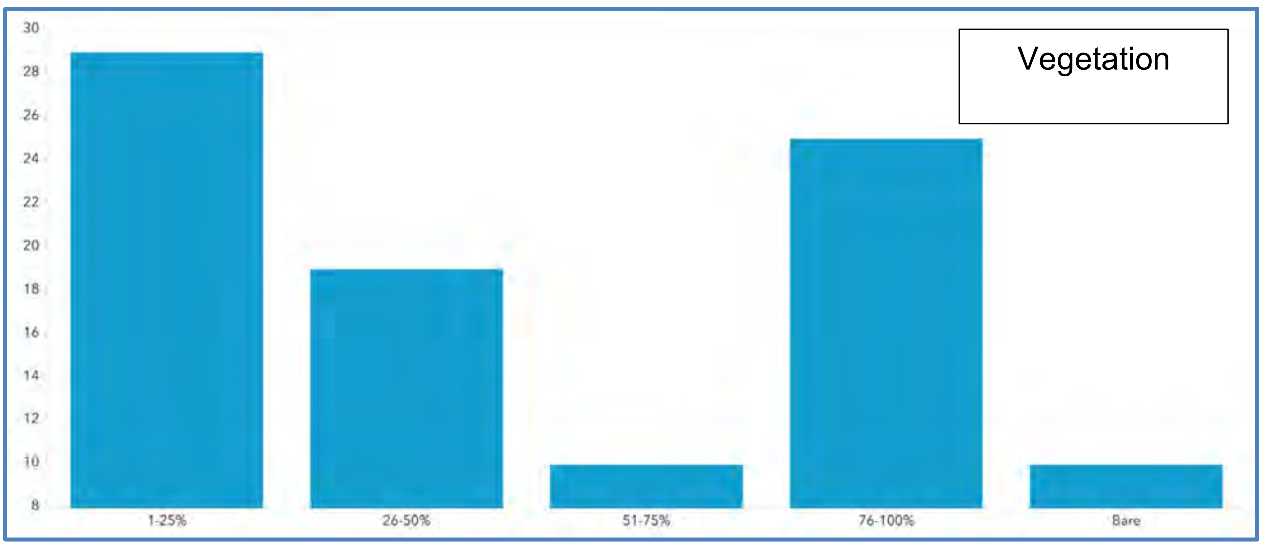

Figure 3-14. Vegetation (by percentage varying from 1-100%).

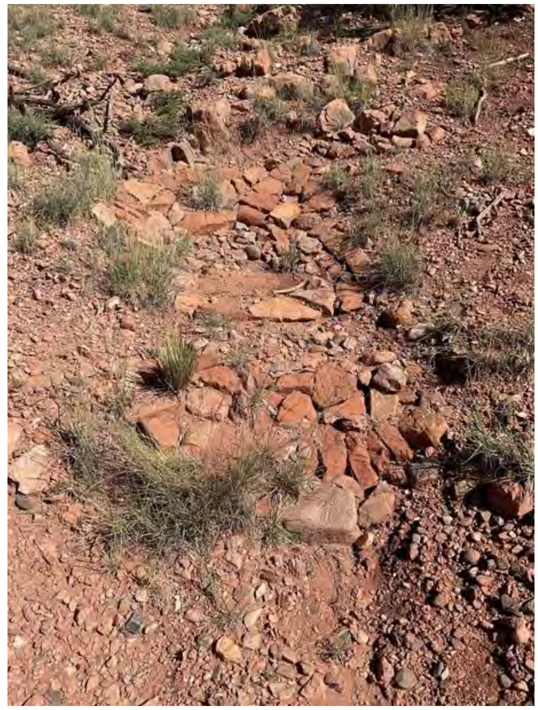

Figure 3-15. Examples of 76-100% vegetated (left) and 1-24% vegetated (right). Locations: -106.6013747, 35.9240822; and -105.942457, 35.44432338, respectively.

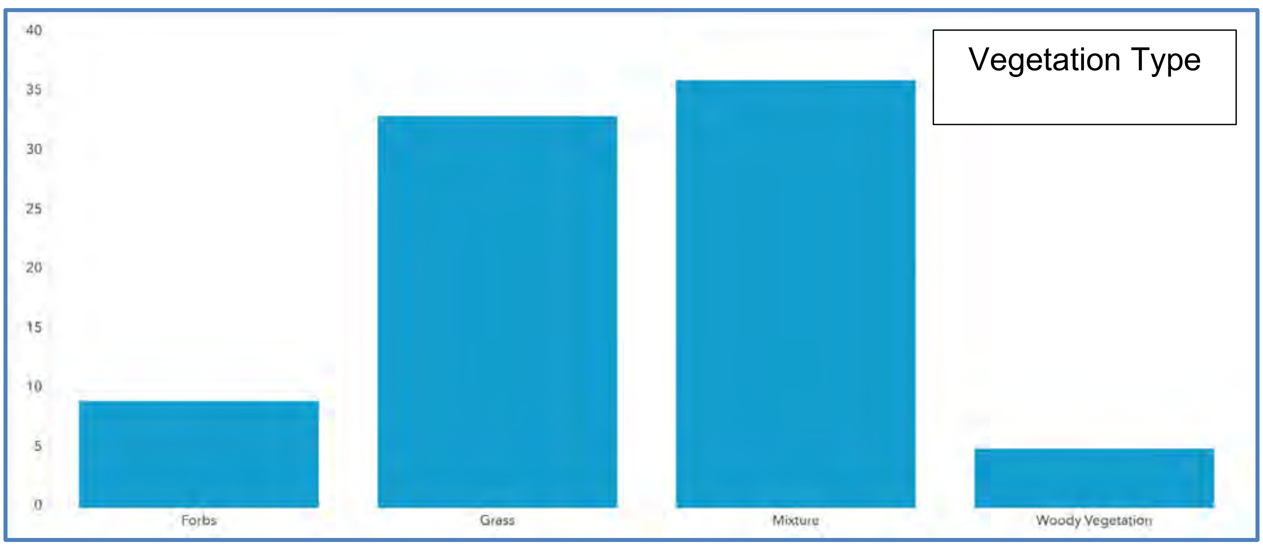

Figure 3-16. Vegetation Type (forbs, grass, mixture, woody vegetation).

<u>Dimensions of a Zuni Bowl and One Rock Dam</u>

The survey included measurements of the Zuni Bowl Pour Over, Lower Pour Over, and distance between Zuni Bowl and One Rock Dam. These metrics were intended to check the design criteria: 1) Zuni Bowl Pour Over = ½ original headcut height; and 2) Distance between Zuni Bowl and One Rock Dam = 6-8X original headcut height. However, it is problematic to assess design criteria after a Zuni Bowl is built and sedimentation has filled in pore space in the bowl. One can no longer measure the former headcut height once it is filled in by the rocks comprising the bowl and the structure is filled with sediment. Therefore, most of the measurements show variations on the two design criteria and it is not possible to validate the original design. However, all of the structures surveyed were either constructed or supervised by individuals trained in Zuni Bowl and One Rock Dam construction.

4. Zuni Bowl/One Rock Dam Workshop

4-1. Workshop Planning and Location

RGR conducted a one-day workshop with NMDOT in Santa Fe. Cameron Weber, Karen Menetrey and Abe Aufdermauer led the workshop, which was located in the training classroom at the NMDOT building on 1120 Cerrillos Road in Santa Fe. There were tentative plans to conduct a multi-day workshop in the classroom and in the field but that was not feasible considering autumn weather variability and clearance requirement lead time for conducting work on NMDOT rights of way.

Instead, a classroom workshop was conducted from 8:30am to noon, and workshop participants took a field trip to Santa Fe Botanical Gardens from approximately 1:00pm to 2:00pm.

Rio Grande consulted with Santa Fe Botanical Gardens to obtain permission to park in their parking lot. RGR also requested project design plans from Santa Fe Botanical Gardens, City of Santa Fe, and Watershed Artisans, Inc. but none were provided.

4-2. Workshop Implementation - Classroom

Fourteen NMDOT participants attended the workshop. See Appendix D for the workshop sign-in sheet. See Appendix E for the workshop agenda and the two slide presentations.

Susan Lime started the morning with an introduction to the project, and the participants introduced themselves.

Ms. Menetrey gave a presentation that covered the anatomy of a headcut, explained how erosion from a headcut progresses and provided examples of headcuts in New Mexico. She then introduced the schematic diagrams for a Zuni Bowl and One Rock Dam and discussed terminology and design criteria. This set the stage for learning how to build a Zuni Bowl and One Rock Dam.

Ms. Weber presented on how to lay out a rock structure, methods and tools for moving rocks, using hand tools safely, and how to order rock from a quarry and evaluate onsite rock sources for use in structures. A photo of the presentation is shown in Figure 4-1. A bound copy of Appendix F was provided to each workshop participant. Note that Appendix F is a draft version and revisions may be made by the authors before its final printing.

Figure 4-1. Classroom portion of the Zuni Bowl workshop. Cameron Weber is demonstrating the use of a Pick Mattock.

After the presentation there was discussion on applicability of Zuni Bowls for road rights of way. NM DOT participants raised questions about constraints along roadways and the maintenance needed on the structures. Comments from the discussion include:

- These structures will be useful in ditches that are parallel to the highways.
- The structures may need to be modified to the locations due to constraints.
- RGR will not be offering advice on how to fit the structures into the road right-of-way, but advising caution that they be used in appropriate situations. These cautions, given in Section 5-4 Recommendations, reflect the need to develop clear qualifying criteria for the application of these structures and to tailor each structure to the conditions and location. Training on the concepts, in addition to the dimensions and materials, will help develop criteria for the application of these structures to roadway drainage infrastructure and right-of-way.

- It would be good to use these structures on small headcuts before they become bigger issues.
- Maintenance is a big concern, but we can teach maintenance while teaching how to build.
- A statewide green stormwater infrastructure task force could build and maintain the structures statewide.
- RGR advises that structures are monitored and maintained within the same year after they are built (after monsoons) and then annually thereafter.

The next workshop agenda item was a desktop exercise during which participants built scaled models of Zuni Bowls and One Rock Dams. RGR had created frames to hold four models, and built one prototype model in advance. The prototype is shown in Figure 4-2. Ms. Weber pointed out the design elements and explained how to build the models.

Figure 4-2. Prototype desktop model of a Zuni Bowl and One Rock Dam built by RGR.

Workshop participants grouped into three teams and worked together to construct the models using the frames, rocks and measuring tapes that were provided. Construction of a desktop model is shown in Figure 4-3.

Figure 4-3. NMDOT workshop participant constructing a desktop model of a Zuni Bowl and One Rock Dam.

After the three models were complete, the entire group evaluated the design and construction, noting any challenges encountered during the construction and flaws in the outcome. Flawed features noted during the critique included:

- Rocks too high above the Zuni Bowl Pour-Over (flow might dislodge the rocks, causing new erosion to progress).
- Gaps between rocks on Zuni Bowl walls where they were pushed into the clay substrate rather than resting on top of the rocks below (subject to shifting by gravity and piping of flow through gaps).
- Height of Lower Pour-Over not uniformly ½ height of Zuni Bowl Pour-Over (it was noted that 1/3 to ½ height is acceptable).

- Height of One Rock Dam not uniform (may create preferential flow paths that result in uneven sediment deposition and new erosion).
- Orientation of rocks in One Rock Dam not optimal (rocks were not oriented with narrow axis aligned perpendicular to flow which reduces the force on an individual rock and hence on the entire structure).
- Rocks not high enough on the sides of the One Rock Dam (might cause flow to erode around the sides).
- A second row of rocks could be placed upstream (on the bowl side) of the Zuni Bowl Pour-Over row for fortification.

The evaluation of the models may have been the most successful part of the workshop. It was clear by the questions that were asked, ensuing discussion, and positive feedback provided, that participants enjoyed building the desktop models and gained considerable understanding about the design and functions of Zuni Bowls and One Rock Dams. Participants voted on the best-built model. NMDOT decided to keep the desktop model prototype and two of the workshop-constructed models for display in conference rooms.

4-3. Workshop Implementation – Field Trip

Eight NMDOT workshop participants and the three RGR instructors departed on the field trip to Santa Fe Botanical Gardens just as inclement weather began. The snowstorm would blanket Santa Fe with approximately 12 inches of snow over the next two days. The group arrived at the Botanical Gardens and walked down the arroyo as the snow began to fall harder. The arroyo bisects the Botanical Gardens and is owned by the City of Santa Fe.

The field trip site has numerous examples of rock structures built by Watershed Artisans, Inc., The RainCatcher Inc, and Southwest Urban Hydrology, LLC in approximately 2014. The structures are intact and embedded with little evidence of new erosion or displacement. Workshop participants were able to see two Zuni Bowl/One Rock Dam structures, several rock rundowns, plunge pools (similar to successive Zuni Bowls on a steep slope, and 1930s-era gabion baskets in the arroyo, before the snow began to obscure the structures. This is shown in Figure 4-4. Because of the deteriorating weather, the field trip itinerary was truncated. Participants were advised that they could come back to the arroyo to see structures at another time as it is public property. A Zuni Bowl in the arroyo is shown in Figure 4-5. There are several other rock structures visible in the arroyo downstream to just beyond the culvert under Camino Corrales.

Figure 4-4. Field trip to Santa Fe Botanical Gardens. Participants examining a Zuni Bowl.

Figure 4-5. Zuni Bowl in the arroyo at Santa Fe Botanical Gardens. Photo taken on a clear day prior to the field trip. Location: -105.928595, 35.665349.

5. Exemplary Controls

5-1. Determination of Exemplary Controls

Exemplary Zuni Bowl and One Rock Dam erosion control structures display the following characteristics:

- Rocks are closely interlocking with little pore space throughout the structure.
- Rocks are stack on the walls so that rock is in contact with rock, and pushed flush against the walls.
- Rocks reach to the lip of the headcut but not higher.
- The structure is functioning as intended to arrest erosion.
- There is no new erosion.
- All rocks are intact.
- The Zuni Bowl and One Rock Dam were built according to design specifications.
- The headcut was laid back, not too steep.
- The structure is recruiting vegetation. The amount of vegetation will vary with the age of the structure and site-specific setting.

Based on the survey results, the two most important criteria for identification of exemplary controls is Condition and Erosion. Table 5-1 lists the surveyed structures that are considered exemplary based on no new erosion, and all rocks intact. Figures 5-1 through 5-18 show photos of the exemplary controls. The best portrayal of the structure was used and identified as upslope or downslope. Note that any or all of the structures may have been exemplary when built, but were not deemed exemplary if they are currently exhibiting new erosion or dislodged or broken rocks. In some cases, structures that would have met the criteria were excluded due to dislodged rocks following historic flooding. In addition, Zuni Bowls that were not built with One Rock Dams are not identified as exemplary structures even though the Zuni Bowl portions may have been built to design specifications and are functioning properly.

Table 5-1. List of Exemplary Controls.

Structure Identifier	Condition	Material	Rock Angularity	Erosion	Sedimenta-tion	Age	Latitude	Longitude
SF Botanical Garden 10	All rocks intact	Mixture of rock types	Angular	No new erosion	Buried	2014	-105.93051	35.664118
Cedro Creek #1	All rocks intact	Sedimentary	Mixed	No new erosion	No additional sediment apparent	2015	-106.38461	35.074242
Juan Tomas #13	All rocks intact	Sedimentary	Mixed	No new erosion	Partially filled	2018	-106.35365	35.04917
Rio Mora NWR #2	All rocks intact	Sedimentary	Partially angular	No new erosion	No additional sediment apparent		-105.05705	35.830395
Rio Mora NWR #12	All rocks intact	Sedimentary	Mixed	No new erosion	Partially buried	2008	-105.0738	35.833692
Sulphur Creek #3	All rocks intact	Igneous	Partially angular	No new erosion	Partially buried	2017	-106.60137	35.924082
Sulphur Creek #14	All rocks intact	Igneous	Partially angular	No new erosion	Partially filled	2017	-106.59143	35.934807
Sulphur Creek #15	All rocks intact	Igneous	Partially angular	No new erosion	Partially filled	2017	-106.58829	35.938025
Sulphur Creek #17	All rocks intact	Igneous	Partially angular	No new erosion	No additional sediment apparent	2017	-106.58082	35.937231
La Jara #1	All rocks intact	Igneous	Mixed	No new erosion	No additional sediment apparent	2018	-106.51879	35.865194
La Jara #2	All rocks intact	Igneous	Partially angular	No new erosion	Partially filled	2018	-106.51879	35.865208
SFCT GAL #1	All rocks intact	Sedimentary	Angular	No new erosion	Partially filled	2021	-105.94196	35.444806
SFCT GAL #2	All rocks intact	Sedimentary	Angular	No new erosion	Partially filled	2021	-105.94186	35.444699
SFCT GAL #6	All rocks intact	Sedimentary	Angular	No new erosion	Partially buried	2021	-105.94246	35.444323
SFCT GAL #8	All rocks intact	Sedimentary	Angular	No new erosion	Partially buried	2022	-105.94289	35.443746
Embudo #4	All rocks intact	Sedimentary	Round	No new erosion	Partially buried	2023	-105.89223	36.182169
Embudo #5	All rocks intact	Igneous	Round	No new erosion	Partially filled	2023	-105.90233	36.184721

Figure 5-1. Santa Fe Botanical Gardens 10. Object ID 1 in the survey. Location: -105.93051, 35.664118. Photo looking upslope.

Figure 5-2. Cedro Creek #1. Object ID 3 in the survey. Location: -106.38461, 35.074242. Photo looking downslope.

Figure 5-3. Juan Tomas #13, Rio Mora NWR. Object ID 14 in the survey. Location: -106.35365, 35.04917. Photo looking upslope.

Figure 5-4. Rio Mora NWR #2. Object ID 35 in the survey. Location: -105.0570489, 35.83039503. Photo looking upslope.

Figure 5-5. Rio Mora NWR #12. Object ID 38 in the survey. Location: -105.073796, 35.83369238. Photo looking downslope.

Figure 5-6. Sulphur Creek #3. Object ID 52 in the survey. Location: -106.6013747, 35.9240822. Photo looking downslope. Structure is obscured by vegetation.

Figure 5-7. Sulphur Creek #14. Object ID 63 in the survey. Location: -106.5914269, 35.93480662   Photo looking downslope. Much of the structure is obscured by vegetation.

Figure 5-8. Sulphur Creek #15. Object ID 64 in the survey. Location: -106.588288, 35.93802508. Photo looking downslope.

Figure 5-9. Sulphur Creek #17. Object ID 66 in the survey. Location: -106.5808215, 35.9372305. Photo looking upslope.

Figure 5-10. La Jara Creek #1. Object ID 79 in the survey. Location: -106.518787235.8651939. Photo looking downslope.

Figure 5-11. La Jara Creek #2. Object ID 80 in the survey. Location: -106.5187878, 35.86520847. Photo looking downslope.

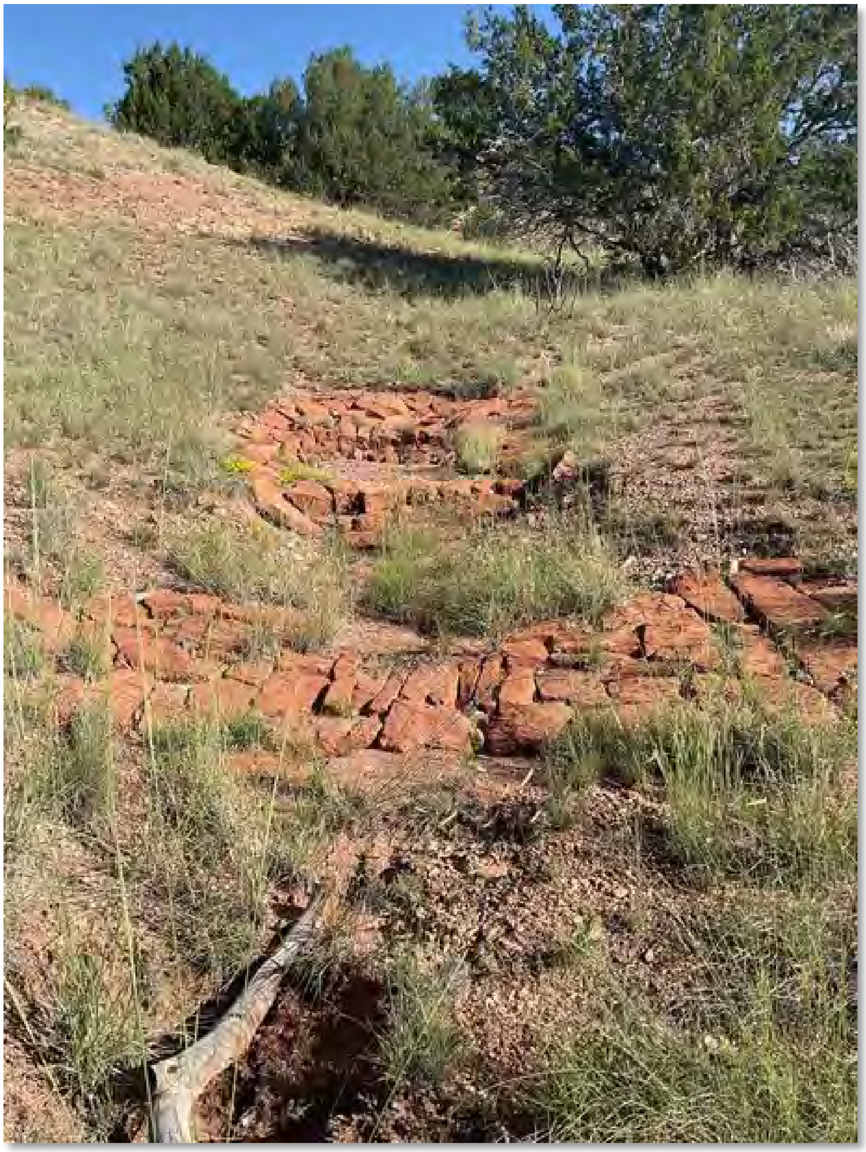

Figure 5-12. SFCT GAL #1. Galisteo Basin. Location: -105.9419599, 35.44480557. Object ID 81 in the survey.

Figure 5-13. SFCT GAL #2. Object ID 82 in the survey. Location: -105.9418646, 35.44469897. Photo looking downslope.

Figure 5-14. SFCT GAL #6. Object ID 86 in the survey. Location: -105.942457, 35.44432338. Photo looking upslope.

Figure 5-15. SFCT GAL #8 Object ID 88 in the survey. Location: -105.9428874, 35.44374573. Photo looking upslope.

Figure 5-16. Embudo #4. Object ID 95 in the survey. Location: -105.892229, 36.18216896. Photo looking downslope.

Figure 5-17. Embudo #5. Object ID 96 in the survey. Location: -105.90233, 36.184721. Photo looking downslope.

Figure 5-18. Rio Mora NWR #12. Object ID 38 in the survey. Location: -105.073796, 35.83369238. Photo looking downslope.

5-2. Site Specific Design Considerations

The design of a rock erosion control structure will need to consider site specific conditions. For instance, multiple drops may warrant multiple Zuni Bowls in succession (plunge pools). A steep slope above or below the Zuni Bowl may necessitate a Rock Rundown structure. A One Rock Dam should still be placed below the hybrid structure to help hold the grade. Zuni Bowls may incorporate in situ rocks such as large boulders and bedrock as part of the structure.

5-3. Source Material Considerations

Minimizing land disturbance is important when considering local rock collection. Collect rock that is on the surface rather than digging rock out and collect from more stable gradual slopes or flatter areas upslope. Collecting from areas upslope of the structure will increase the likelihood the soil exposed will be captured by the grade control structure.

If it is necessary to source rip-rap rock for building structures, using a quarry source will require special considerations (NRCS Conservation Practice 643). NMDOT Districts regularly source materials including rip rap and boulders from local quarries (S. Morgenstern, pers. Communication, 2024). The best match for rock to build Zuni Bowls and One Rock Dams will require more coordination than Districts are accustomed to since, for example, Class A Rip Rap 4-8” is defined through tests of absorption, weight, abrasion, sulfate soundness, and freeze-thawing. These standards are different than the needs for building Zuni Bowls and One Rock Dams, which focus on angularity to ensure the rocks can be manually fitted together. If possible, make a trip to the quarry and speak with the operator about the project needs, especially if you will be using the quarry regularly as a source for restoration materials. Request the sieve analysis or ask about the rock sorter with your supplier to understand what options they have for selecting for the material you need. To ensure more angular rocks of the right size range, request the quarry to provide angular granitic rock between 6-18 inches in length. Seventy percent of the material should be screened through a 6 inch “grizzly” (rock sorter with vertical bars – see photo). The over-burden from this pass then should be put over a 12-inch grizzly to generate 30% of the total load needed. Very large rocks, small rock fragments and gravels are excluded using this process. This requires requesting the quarry to sort the material twice and they may charge extra for this, but results in all rock that is delivered being usable. This reduces hauling costs, which is usually more expensive than material costs.

Naturally angular rock with angled edges that lock into one another make a better choice than round rock. Avoid blast rock when possible as this material is more difficult to work with and looks unnatural in the landscape (Lancaster, 2022). Rock size should be larger than 90% of the typical naturally deposited rock in the channel because this size class is not as likely to be mobilized during a flood. However, using excessively large rock will cause additional turbulence that could undermine the structure. Using local rock is generally preferable to importing rock. In a sandy channel without rock in the system, it is best to import rock with an average size of 1/8th the width of the channel. For example, in a 6-foot wide channel, use 8-10-inch rock for constructing a One Rock Dam.

5-4. Recommendations

Many Zuni Bowls and One Rock Dams are already in place across the landscape and are functioning as designed. This study focused on the exemplary structures, but it is certainly possible for these structures to be located or constructed in ways that cause more harm than good.

In conversation with contributors to this study, we heard most often that these structures must always be tailored to the unique location and conditions, and that a standard size Zuni Bowl does not exist. We also heard that the enthusiastic application of Zuni Bowls to culvert scour could lead to the concept of Zuni Bowls being wrongly faulted and the technique undermined. The overarching message from these professionals was to take a cautious approach and to get training in the concepts, not only on the dimensions.

Experience can be gained by building structures with volunteers who often have a decade or more of experience through the many volunteer events hosted by the Albuquerque Wildlife Federation (https://abq.nmwildlife.org/projects.html) and NMDOT should watch for upcoming formalized training opportunities through Albuquerque Wildlife Federation. Quivira Coalition holds one or two project weekends per year with opportunities to learn alongside others. The ARID LID Coalition has organized trainings for the maintenance of green stormwater infrastructure.

These trainings would provide valuable and relevant experience for NMDOT maintenance staff. Any of these non-profits could be contracted to provide a training specifically for NMDOT personnel. Local restoration professionals are available through statewide price agreements to identify appropriate locations and build these structures on NMDOT rights-of-way and this approach could be used to give NMDOT staff the opportunity to learn through hands-on experience with professionals in construction and, importantly, site evaluation. NMDOT could task a local restoration professional with determining criteria for the suitability and adaptation of these structures to culvert outlets and roadside ditches and right-of-way infrastructure.

The next phase of this research should certainly include a close consideration of the design guidance and validation. This could lead to the addition of a field in the CAMP database to determine if a Zuni Bowl-One Rock Dam design is warranted for the given location. It would also help to develop and include criteria for Zuni Bowl-One Rock Dam design to the CAMP Culvert Inventory Handbook under Erosion Controls or Channel Scour.

Regular inspection and maintenance of structures is necessary. We recommend annual or bi-annual planned inspection and maintenance, including observations about why any damage was caused.

Roadways are subject to additional forms of disturbance such as emergency vehicles, pedestrian paths, and debris that the locations surveyed here don’t experience. Influences like these need to be evaluated as part of the design guidance.

Adaptations to these structures are sometimes necessary. Including a header of flat rock at grade upstream of the Zuni Bowl may be a modification appropriate for the additional stressors experienced in roadways drainages.

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List of Appendices

Appendix A. Zuni Bowl Reference List

Zuni Bowl and One Rock Dam Reference List

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Appendix B. Zuni Bowl Survey Data_Excel

ObjectID	GlobalID	CreationDate	Creator	EditDate	Editor	Date and Time
1	1767f713-c01d-449	05/10/2024 13:47:21.845	RioGrandeReturn1	11/20/2024 15:34:15.610	RioGrandeReturn1	04/19/2024 20:31:08.118
2	3c57f6e5-363e-4d4	05/10/2024 14:05:20.392	RioGrandeReturn1	07/24/2024 21:29:02.747	RioGrandeReturn1	04/19/2024 21:34:12.840
3	00e9b285-0417-43	05/15/2024 01:28:22.839	RioGrandeReturn1	07/24/2024 21:30:20.831	RioGrandeReturn1	05/09/2024 14:40:02.558
4	ade2abec-7326-4b4	05/15/2024 01:28:53.198	RioGrandeReturn1	07/24/2024 21:30:34.694	RioGrandeReturn1	05/09/2024 15:03:55.425
5	06f675f7-34cf-4868	05/15/2024 01:29:24.838	RioGrandeReturn1	11/20/2024 18:46:05.961	RioGrandeReturn1	05/09/2024 15:26:05.222
6	4b34c364-56f8-4cf	05/15/2024 01:29:56.954	RioGrandeReturn1	11/20/2024 18:51:13.194	RioGrandeReturn1	05/09/2024 15:54:48.387
7	6bb9cf04-54a0-4db	05/15/2024 01:30:29.394	RioGrandeReturn1	11/20/2024 18:40:14.335	RioGrandeReturn1	05/09/2024 16:14:57.021
8	ebd5fe58-3e04-43c	05/15/2024 01:31:03.053	RioGrandeReturn1	11/20/2024 18:39:27.097	RioGrandeReturn1	05/09/2024 16:21:54.842
9	bf1ccc9c-114b-4c7	05/15/2024 01:31:34.689	RioGrandeReturn1	11/20/2024 18:36:51.649	RioGrandeReturn1	05/09/2024 16:34:29.361
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14	2b31cbe8-f82f-42b	05/15/2024 01:34:08.651	RioGrandeReturn1	11/20/2024 18:32:32.808	RioGrandeReturn1	05/09/2024 18:00:45.824
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83	8b7ff4f8-b56f-443a	08/20/2024 19:12:47.952		08/20/2024 19:12:47.952		8/20/24 15:26
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88	6cfbc6c7-20b6-49f	08/20/2024 19:19:47.267		08/20/2024 19:19:47.267		08/20/2024 16:26:23.240
89	266a52f7-a914-451	10/03/2024 15:32:47.233	susan.lime_NMDOT	11/05/2024 14:56:42.461	RioGrandeReturn1	9/1/24 19:46
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91	b9cae286-f64c-4d8	10/03/2024 15:33:56.177	susan.lime_NMDOT	11/05/2024 14:56:01.892	RioGrandeReturn1	9/1/24 19:55
92	e3fe6964-6184-467	10/24/2024 00:42:34.742		11/17/2024 03:25:05.750	RioGrandeReturn1	10/23/2024 18:44:29
93	229fbdd0-b568-40	10/24/2024 00:42:41.168		11/17/2024 03:25:20.779	RioGrandeReturn1	10/23/2024 20:02:38
94	e8a3f2a3-4f4a-44a	11/04/2024 23:51:44.606		11/17/2024 03:24:23.990	RioGrandeReturn1	10/30/24 20:28
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96	3eb33c0e-be1e-43	11/04/2024 23:51:50.969		11/17/2024 03:23:42.143	RioGrandeReturn1	10/31/24 5:12
97	4ca9b11b-6663-48	11/04/2024 23:51:51.849		11/17/2024 03:24:06.999	RioGrandeReturn1	10/30/24 21:02

Surveyor Name	Structure Identifier	Condition	Other - Condition	Reason for Degraded Condition	Construction Material
Abe Aufdermauer	SF Botanical Garden 10	All rocks intact			Mixture of rock types
Abe Aufdermauer	Camino Rio	All rocks intact			Igneous
Abe Aufdermauer	Cedro Creek #1	All rocks intact		Unknown	Sedimentary
Abe Aufdermauer	Cedro Creek #2	Some rocks dislodged or broken		Unknown	Sedimentary
Abe Aufdermauer	Cedro Creek #3	Some rocks dislodged or broken			Sedimentary
Abe Aufdermauer	Cedro Creek #8 ORD	All rocks intact			Sedimentary
Abe Aufdermauer	Cedro Creek #7 ORD	All rocks intact			Sedimentary
Abe Aufdermauer	Cedro Creek #6 ORD	All rocks intact			Sedimentary
Abe Aufdermauer	Cedro Creek #5 ORD	All rocks intact			Sedimentary
Abe Aufdermauer	Cedro Creek #4 ORD	All rocks intact			Sedimentary
Abe Aufdermauer	Juan Tomas #16 ORD	All rocks intact			Sedimentary
Abe Aufdermauer	Juan Tomas #15 ORD	Some rocks dislodged or broken		Unknown	Sedimentary
Abe Aufdermauer	Juan Tomas #14 ORD	All rocks intact			Sedimentary
Abe Aufdermauer	Juan Tomas #13	All rocks intact			Sedimentary
Abe Aufdermauer	Juan Tomas #12 ORD	All rocks intact			Sedimentary
Abe Aufdermauer	Juan Tomas #11 drop inlet	All rocks intact			Sedimentary
Abe Aufdermauer	Juan Tomas #10 ORD	All rocks intact			Sedimentary
Abe Aufdermauer	Juan Tomas #9 ORD	All rocks intact			Sedimentary
Abe Aufdermauer	Juan Tomas #8	Some rocks dislodged or broken		Unknown	Sedimentary
Abe Aufdermauer	Juan Tomas #7 ORD	All rocks intact			Sedimentary
Abe Aufdermauer	Juan Tomas #6	All rocks intact			Sedimentary
Abe Aufdermauer	Pine Flats North #1 ORD	All rocks intact			Sedimentary
Abe Aufdermauer	Pine Flat North #2 ORD	All rocks intact			Sedimentary
Abe Aufdermauer	Pine Flat #3	All rocks intact			Sedimentary
Abe Aufdermauer	Pine Flat North #4 ORD	All rocks intact			Sedimentary
Abe Aufdermauer	Pine Flat #5 ORD	Some rocks dislodged or broken		Human interference (vehicles or	Sedimentary
Abe Aufdermauer	Rio Mora NWR #10	All rocks intact			Sedimentary
Abe Aufdermauer	Rio Mora NWR #9	Some rocks dislodged or broken		Dislodged by water	Sedimentary
Abe Aufdermauer	Rio Mora NWR #8	All rocks intact			Sedimentary
Abe Aufdermauer	Rio Mora NWR #7	Some rocks dislodged or broken		Dislodged by water	Sedimentary
Abe Aufdermauer	Rio Mora NWR #6	All rocks intact			Sedimentary
Abe Aufdermauer	Rio Mora NWR #5	Some rocks dislodged or broken		Dislodged by water	Sedimentary
Abe Aufdermauer	Rio Mora NWR #4	All rocks intact			Sedimentary
Abe Aufdermauer	Rio Mora NWR #3	All rocks intact			Sedimentary

Abe Aufdermauer	Rio Mora NWR #2	All rocks intact		Sedimentary
Abe Aufdermauer	Rio Mora NWR #1	All rocks intact		Sedimentary
Abe Aufdermauer	Rio Mora NWR #11	All rocks intact		Sedimentary
Abe Aufdermauer	Rio Mora NWR #12	All rocks intact		Sedimentary
Abe Aufdermauer	Rio Mora NWR. #13	All rocks intact		Sedimentary
Abe Aufdermauer	Rio Mora NWR #14	All rocks intact		Sedimentary
Abe Aufdermauer	Rio Mora NWR #15	All rocks intact		Sedimentary
Abe Aufdermauer	Rio Mora NWR #16	All rocks intact		Sedimentary
Abe Aufdermauer	Rio Mora NWR #17	All rocks intact		Sedimentary
Abe Aufdermauer	Rio Mora NWR #18	Some rocks dislodged or broken	Dislodged by water	Sedimentary
Abe Aufdermauer	Rio Mora NWR #19	All rocks intact		Sedimentary
Abe Aufdermauer	Rio Mora NWR #20	All rocks intact		Sedimentary
Abe Aufdermauer	Rio Mora NWR #21	All rocks intact		Sedimentary
Abe Aufdermauer	Rio Mora NWR #22	Some rocks dislodged or broken	Unknown	Sedimentary
Abe Aufdermauer	Rio Mora NWR #23	Some rocks dislodged or broken	Dislodged by water	Sedimentary
Abe Aufdermauer	Sulphur Creek #1	All rocks intact		Igneous
Abe Aufdermauer	Sulphur Creek #2	Some rocks dislodged or broken	Dislodged by water	Igneous
Abe Aufdermauer	Sulphur Creek #3	All rocks intact		Igneous
Abe Aufdermauer	Sulphur Creek #4	Some rocks dislodged or broken	Dislodged by water	Igneous
Abe Aufdermauer	Sulphur Creek #5	Some rocks dislodged or broken	Dislodged by water	Igneous
Abe Aufdermauer	Sulphur Creek #6	All rocks intact		Igneous
Abe Aufdermauer	Sulphur Creek #7	Some rocks dislodged or broken	Dislodged by water	Igneous
Abe Aufdermauer	Sulphur Creek #8	Some rocks dislodged or broken	Dislodged by water	Igneous
Abe Aufdermauer	Sulphur Creek #9	All rocks intact		Igneous
Abe Aufdermauer	Sulphur Creek #10	All rocks intact		Igneous
Abe Aufdermauer	Sulphur Creek #11	Some rocks dislodged or broken	Dislodged by water	Igneous
Abe Aufdermauer	Sulphur Creek #12	All rocks intact		Igneous
Abe Aufdermauer	Sulphur Creek #13	Some rocks dislodged or broken	Dislodged by water	Igneous
Abe Aufdermauer	Sulphur Creek #14	All rocks intact		Igneous
Abe Aufdermauer	Sulphur Creek #15	All rocks intact		Igneous
Abe Aufdermauer	Sulphur Creek #16	All rocks intact		Igneous
Abe Aufdermauer	Sulphur Creek #17	All rocks intact		Igneous
Abe Aufdermauer	Sulphur Creek #18	All rocks intact		Igneous
Cameron Weber	Rodondo 1	Some rocks dislodged or broken	Dislodged by water	Igneous
Cameron Weber	Redondo 2	Some rocks dislodged or broken	Dislodged by water	Igneous

Cameron Weber	Redondo 3	Some rocks dislodged or broken	Dislodged by water	Igneous
Cameron Weber	Santa Rosa 1	Some rocks dislodged or broken	Dislodged by water	Igneous
Cameron Weber	Santa Rosa 2	Some rocks dislodged or broken	Dislodged by water	Igneous
Cameron Weber	Santa Rosa 3	Some rocks dislodged or broken	Dislodged by water	Igneous
Cameron Weber	Santa Rosa 4	Some rocks dislodged or broken	Dislodged by water	Igneous
Cameron Weber	Santa Rosa 5	All rocks intact		Igneous
Cameron Weber	Santa Rosa 6	Some rocks dislodged or broken	Dislodged by water	Igneous
Cameron Weber	Santa Rosa 7	Some rocks dislodged or broken	Dislodged by water	Igneous
Cameron Weber	Santa Rosa 8	Some rocks dislodged or broken	Dislodged by water	Igneous
Cameron Weber	La Jara 1	All rocks intact		Igneous
Cameron Weber	La Jara 2	All rocks intact		Igneous
Karen Menetrey	SFCT GAL #1	All rocks intact		Sedimentary
Karen Menetrey	SFCT GAL #2	All rocks intact		Sedimentary
Karen Menetrey	SFCT GAL #3	All rocks intact		Mixture of rock types
Karen Menetrey	SFCT GAL #4	All rocks intact	Unknown	Mixture of rock types
Karen Menetrey	SFCT GAL #5	Some rocks dislodged or broken	Dislodged by water	Sedimentary
Karen Menetrey	SFCT GAL #6	All rocks intact		Sedimentary
Karen Menetrey	SFCT GAL #7	All rocks intact		Sedimentary
Karen Menetrey	SFCT GAL #8	All rocks intact		Sedimentary
Cameron Weber	Susan Lime #3	Some rocks dislodged or broken	Dislodged by water	Mixture of rock types
Cameron Weber	Susan Lime #2	Some rocks dislodged or broken	Dislodged by water	Mixture of rock types
Cameron Weber	Susan Lime #1	All rocks intact		Mixture of rock types
Cameron Weber	Embudo #1	All rocks intact		Igneous
Cameron Weber	Embudo #2	All rocks intact		Igneous
Cameron Weber	Embudo #3	All rocks intact		Igneous
Cameron Weber	Embudo #4	All rocks intact		Metamorphic
Cameron Weber	Embudo #5	All rocks intact		Igneous
Cameron Weber	Embudo #6	All rocks intact		Igneous

Other - Construction Material	Additional information on Construction Material
	Basalt
	all limestone from roadway slope blast rock. Sourced from GCC aggregate plant
	All limestone
	All limestone
	All limestone
	All limestone
	All limestone
	All limestone
	All limestone imported
	All limestone imported
	All limestone imported
	All limestone imported
	All limestone imported
	Limestone and some sandstone some rock local
	All limestone imported
	All imported limestone
	All imported limestone
	All imported limestone
	All imported limestone
	Native limestone
	All native limestone
	Native limestone
	Native limestone and sandstone
	Native limestone and sandstone
	Native sandstone
	Native sandstone
	Native sandstone
	Native rock
	Native sandstone
	Native sandstone
	Native sandstone
	Native sandstone

Native sandstone
Native sandstone
Native sandstone
All native limestone
All native sandstone
All native sandstone with some limestone
All native sandstone
All native sandstone
All native sandstone
Native sandstone
Sandstone
All sandstone
All sandstone
Mostly sandstone some limestone
Mostly sandstone some limestone

Sandstone
Sandstone
Sandstone and some igneous gathered on site
Sandstone and igneous collected on site. Sandstone from a quarry between Bernal and Romeroville.
Sandstone
Sandstone
Sansatone
Sandstone
Working based on precious visit, this strucure has collected 6 inches of fine sediment
Natural chanmel down stream of one rock dam
Scour channel downstream. Mulch sock stabilization of bank to the left (facing downstream).

Granite, cobble
Limestone
Granite
Granite

Rock Angularity	Zuni Bowl Rock Size	Other - Zuni Bowl Rock Size	Zuni Bowl Length
Angular	6-12"		3.75
Round	25-36"		10
Mixed (some round, some angular	13-18"		12.4
Partially angular	19-24"		10.1
Partially angular	other	Very large 5’ plus native rock used as basis for structure. Other rocks sedimented over	14.6
Angular			
Angular			
Angular	6-12"		
Partially angular			
Angular			
Partially angular			
Angular			
Angular			
Mixed (some round, some angular	6-12"		5.5
Angular			
Angular			
Angular			
Angular			
Angular	6-12"		7.3
Angular			
Angular			
Angular			
Angular			
Angular			
Partially angular			
Partially angular			
Partially angular			
Partially angular			
Partially angular			
Partially angular	6-12"		4
Partially angular			
Angular			
Angular			
Partially angular			

Partially angular	6-12"	8
Mixed (some round, some angular	6-12"	22
Mixed (some round, some angular		
Mixed (some round, some angular	6-12"	7
Partially angular		
Partially angular		
Angular		
Partially angular		
Angular		
Mixed (some round, some angular		
Angular	6-12"	11
Angular	6-12"	8.5
Mixed (some round, some angular	6-12"	15
Mixed (some round, some angular	6-12"	13
Partially angular	6-12"	15
Angular		
Partially angular	19-24"	18.3
Partially angular	6-12"	6.1
Partially angular	6-12"	8.3
Angular	6-12"	6
Partially angular		
Angular	6-12"	4.9
Angular	13-18"	8.8
Partially angular		
Partially angular	25-36"	9.5
Partially angular	25-36"	13.3
Partially angular	19-24"	12
Partially angular	13-18"	7.1
Partially angular	25-36"	12
Partially angular	13-18"	10.3
Partially angular	6-12"	16.6
Partially angular	13-18"	10.9
Partially angular		
Partially angular		
Partially angular		

Partially angular		
Partially angular	13-18"	9
Partially angular	13-18"	7
Partially angular	6-12"	5.7
Partially angular	19-24"	19.7
Mixed (some round, some angular	19-24"	7.6
Partially angular	25-36"	21.4
Mixed (some round, some angular	25-36"	23.2
Mixed (some round, some angular	25-36"	21
Mixed (some round, some angular	13-18"	7.8
Partially angular	13-18"	6.1
Angular	6-12"	8.9
Angular	6-12"	6.4
Angular	6-12"	6.9
Angular	6-12"	4.7
Angular	6-12"	5.6
Angular	6-12"	5.3
Angular	6-12"	4.5
Angular	6-12"	7.0
Round		
Partially angular		
Round	6-12"	6.5
Round	6-12"	6.25
Round	6-12"	6.25
Round	6-12"	6.6

Zuni Bowl Width	Zuni Bowl Height	Lower Pour Over Height	Erosion	Other - Erosion
3.75	.83	0	No new erosion	
9.33	1.75	0.75	No new erosion	
11.9	1.5	0.8	No new erosion	
10	2.2	1.7	No new erosion	
12.1	1.4	0.8	No new erosion	
			No new erosion	
			No new erosion	
			No new erosion	
			No new erosion	
			No new erosion	
			No new erosion	
			No new erosion	
6.7	0.9	0.8	No new erosion	
			No new erosion	
			No new erosion	
			No new erosion	
			No new erosion	
6.5	1.5	0.6	Erosion around sides	
			Erosion around sides	
			No new erosion	
			No new erosion	
			No new erosion	
			No new erosion	
			No new erosion	
			No new erosion	
			No new erosion	
			No new erosion	
6	1.3	0.9	No new erosion	
			Erosion around sides	
			No new erosion	
			No new erosion	
			No new erosion	

6	2.1	0.8	No new erosion
20.5	3.6	0.9	No new erosion
			No new erosion
8	1.1	0.9	No new erosion
			No new erosion
			No new erosion
			No new erosion
			No new erosion
			No new erosion
			No new erosion
11	1.4	0.2	No new erosion
10	2.1	0.8	No new erosion
16	2.5	0.5	No new erosion
12	3.5	1	No new erosion
10	3.1	1	Erosion around sides
			Undercutting
16.4	3.4	1.3	Undercutting
5.9	1.3	0.3	No new erosion
8	1.3	0.1	Undercutting
10	2.8	0.6	Undercutting
			No new erosion
4.8	1.2	0.4	Undercutting
6	2	0.9	Undercutting
13.5	4.3	2.2	No new erosion
11.4	2.6	0.3	
16.1	3	1.6	No new erosion
9.3	2	0.9	No new erosion
20.6	3	0.1	No new erosion
10.7	1.4	0.9	No new erosion
16.2	2.2	0	No new erosion
11.8	1.5	0.7	No new erosion
			No new erosion
			No new erosion
			Erosion around sides

			Erosion around sides	
4.4	1.5	1.1		
5.3	1.6	.1	other	
5.4	1.7	1.1	No new erosion	
14.4	1.8	.6	No new erosion	
19.5	1.5	.2	Undercutting	
23.1	2.7	1.1	Undercutting	
20.8	3.4	0.6	Undercutting	
20.4	2.3	0.9	Undercutting	
7	1.2	0.6	No new erosion	
7	0.9	0.6	No new erosion	
7.5	1.5	.2	No new erosion	
4.5	.9	.5	No new erosion	
7.7	1.0	.9	other	A little erosion between ZB and ORD due to steep slope.
5.1	1.1	.4	other	Erosion between ZB and ORD due to steep slope
5.3	2.0	.1	Undercutting	
4.2	1.4	.1	No new erosion	
4.7	1.0	.3	No new erosion	
5.8	.9	.1	No new erosion	
			No new erosion	
4.5	1.2	1.5	Undercutting	
4.8	2.2	.8	No new erosion	
5	2.5	.8	No new erosion	
4	1.6	1	Erosion around sides	

Sedimentation (for Zuni Bowl)	Other - Sedimentation (for Zuni Bowl)	Vegetation	Vegetation Type	One Rock Dam Rock Size	Other - One Rock Dam Rock Size
Buried		Bare		6-12"	
Partially filled		Bare			
No additional sediment apparent		1-25%	Grass	6-12"	
No additional sediment apparent		51-75%	Mixture	6-12"	
Buried		26-50%	Mixture	6-12"	
		76-100%	Grass	13-18"	
Buried		76-100%	Grass	19-24"	
Partially buried		76-100%	Grass	6-12"	
Buried		76-100%	Grass	6-12"	
Partially buried		76-100%	Mixture	6-12"	
No additional sediment apparent		Bare		6-12"	
Buried		1-25%	Woody Vegetation	13-18"	
Partially buried		1-25%	Forbs	6-12"	
Partially filled		Bare		13-18"	
No additional sediment apparent		Bare		6-12"	
Partially filled		Bare			
Partially filled		1-25%	Grass	6-12"	
Partially buried		26-50%	Mixture	6-12"	
Partially buried		1-25%	Mixture	6-12"	
Buried		26-50%	Grass	6-12"	
Partially filled		1-25%	Mixture	6-12"	
Buried		1-25%	Forbs	13-18"	
Partially filled		1-25%	Mixture	6-12"	
Partially buried		Bare		6-12"	
Partially buried		Bare		6-12"	
Partially filled		1-25%	Forbs	6-12"	
		51-75%	Mixture	6-12"	
		26-50%	Mixture	6-12"	
		76-100%	Grass	13-18"	
Partially filled		51-75%	Mixture	13-18"	
		26-50%	Grass	13-18"	
		26-50%	Grass	6-12"	
		76-100%	Grass	13-18"	
		26-50%	Grass	13-18"	

No additional sediment apparent	26-50%	Mixture	6-12"
Partially buried	26-50%	Grass	
	76-100%	Mixture	6-12"
Partially buried	76-100%	Mixture	6-12"
	76-100%	Woody Vegetation	13-18"
	76-100%	Woody Vegetation	6-12"
	51-75%	Woody Vegetation	13-18"
	76-100%	Grass	6-12"
	76-100%	Grass	6-12"
	76-100%	Woody Vegetation	6-12"
Partially filled	26-50%	Grass	
No additional sediment apparent	76-100%	Grass	
Partially filled	26-50%	Forbs	
Partially filled	1-25%	Forbs	6-12"
Partially filled	26-50%	Forbs	6-12"
	76-100%	Mixture	6-12"
Partially filled	51-75%	Grass	
Partially buried	76-100%	Mixture	6-12"
Partially filled	76-100%	Mixture	6-12"
Partially filled	76-100%	Mixture	6-12"
	26-50%	Mixture	13-18"
Partially filled	76-100%	Mixture	
Partially filled	51-75%	Mixture	
			13-18"
Partially filled	76-100%	Mixture	
Partially buried	76-100%	Mixture	
Partially buried	51-75%	Grass	
Partially filled	26-50%	Mixture	6-12"
Partially filled	76-100%	Grass	13-18"
Partially filled	76-100%	Mixture	19-24"
Partially filled	76-100%	Grass	
No additional sediment apparent	1-25%	Mixture	6-12"
	51-75%	Mixture	6-12"
	Bare		6-12"
	1-25%	Mixture	6-12"

	1-25%	Grass	6-12"
Partially buried	1-25%	Grass	
Partially buried	1-25%	Mixture	6-12"
Partially filled	26-50%	Mixture	
Partially buried	26-50%	Mixture	
Partially buried	1-25%	Grass	
Partially buried	26-50%	Grass	
Partially buried	1-25%	Grass	19-24"
Partially filled	51-75%	Grass	
No additional sediment apparent	1-25%	Mixture	6-12"
Partially filled	1-25%	Mixture	13-18"
Partially filled	1-25%	Mixture	6-12"
Partially filled	1-25%	Mixture	6-12"
Partially filled	1-25%	Mixture	6-12"
Partially filled	1-25%	Grass	6-12"
Partially filled	1-25%	Grass	6-12"
Partially buried	1-25%	Grass	6-12"
Partially filled	1-25%	Grass	
Partially buried	1-25%	Grass	6-12"
	1-25%	Forbs	6-12"
	26-50%	Grass	6-12"
No additional sediment apparent	Bare		6-12"
Partially buried	51-75%	Mixture	6-12"
Partially filled	26-50%	Forbs	6-12"
Partially filled	1-25%	Forbs	6-12"

One Rock Dam Length	One Rock Dam Width	One Rock Dam Height	Distance between Zuni Bowl and One Rock Dam	Age of Zuni Bowl/One Rock Dam
1	5	0.5	6.75	2014
6	12.3	0.9	6.9	2015
7.5	12.6	0.5	9.4	2015
3.5	12	0.25		2015
5.2	13.8	0.9		2012
5.3	31.6	0.9		2012
9	27.3	1.2		2012
6.3	8.7	0.8		2012
6	12.4	1.2		2012
7.8	21	1		2024
5.5	19.5	1		2018
5	8.8	1.3		2018
3.5	7	1	3.5	2018
6	9.5	1.3		2024
				2018
2.6	5	0.8		2018
4	5	0.7		2018
4.6	3	0.2	0.5	2018
6	7.5	0.9		2018
9	6	0.9		2018
6.4	21.3	2		2018
7	10	12		2018
8	14.7	1.5		2018
6	9	0.8		2018
5.8	10	0.6		2018
6	19.5	0.5		
7	18	0.3		
9	15	1.4		
5	12	0.6	7.5	
7.2	15.1	1.1		
7	19.5	2		
6	22	0.2		
5.5	16	1.3		

5.5	13	1	20	
6.1	21	0.6		2008
2.5	10	1	8.1	2008
7.3	18	1.2		2008
5	20	0.8		2010
6	12	1.2		2010
7.4	11.5	0.8		2010
12.5	13	1		2010
14	18	0.5		2010
				2021
5.9	5.6	0.8	15	2024
3.5	9	0.8	17	
7.3	4.4	2.7		2017
				2017
6.5	10.9	1.3	6.6	2017
6.5	10.9	1.3	3.7	2017
6.5	10.9	1.3	6.8	2017
6.7	18.5	1		2017
				2017
4.3	11.4	1.2		2017
				2017
				2017
				2017
5.3	6.3	1.3	14.2	2017
5.3	14.5	0.5	7	2017
3	8	0.8	4.6	2017
				2017
5	8.5	1	2.6	2017
4.7	20.9	0.8		2017
3.3	3.1	0.5		2020
2.8	3.8	0.7		2020

2.2	3.3	0.7		2020
				2013
4	4	.4	3.4	2013
				2013
				2010
				2010
				2010
9	11.5	0.8	22.7	2010
				2010
3.4	6.5	0.3	0.8	2018
1.7	6.3	1	0.1	2018
3.7	10.2	.2	4.7	2021
2.7	5.8	.4	4.3	2021
3.7	9.4	.4	7.5	2023
3.3	3.8	.2	3.5	2023
2.5	4.5	.1	12.6	2021
2.3	4.8	.3	1.0	2021
				2022
2.0	6.3	.2	2.5	2022
3.4	16.1	0.3		2023
2.7	3.9	0.3		2023
3.25	6.0	.4	7	2023
3.4	4.4	.8	7.75	2023
2.6	2.9	.6	9	2023
2.4	3.9	.4	4.6	2023

Difference between ZB and ORD Condition

ORD is 5% intact. ZB is 95% intact

ORD downstream edge erosion

Some rocks dislodged in ZB and less vegetated

ORD buried and willow recruitment

Middle half of ORD dislodged

ORD is mostly dislodged ZB is missing a few rocks

ZB nearly entirely intact. ORD cut around and center rocks dislodged. Steep reach.

ORD center rocks dislodged

ORD very sedimented

Additional Notes
Rock appears to be locally sourced
No ORD. Third in a series of ZBs on a steep slope. Imported rock used. Some small rock chinking (local material) is dislodged.
Elms growing throughout structure. Human trail on right bank may lead to future erosion. 30 feet from roadway above creek.
ORD wing on left bank of ZB ties into edge of ZB
70% of structure sedimented

Ties to toe of slope of roadway captures roadway runoff. Break in road right of way armor
Repair made second layer added upstream maybe 2015. Original rock 90% buried and vegetated
Second downstream layer added in 2015
Minor repair in 2015. Many elm saplings
Very recently built. 1st structure in drainage below forest road. Adjacent forest thinned/masticated. Increased erosion and sediment rate. At junction of FS252 and FS542
Roadway drainage

Very recent repair
Recently built roadway drainage
30” oval flat bottom corrugated steel culvert
Two lobed head cut immediately upstream

100 ft upstream of 5’ flat bottom culvert
Large front rocks filled behind with smaller rocks
Built onto bedrock

Mountain bike trail through middle of structure dislodged rocks
Old road crossing directly above the structure sedimenting due to ORD grade control
Old road crossing of arroyo above the structure. Willow recruitment in structure and captured sediment upstream. Rocks dislodged in thalweg along length
Pedestrian or cattle path around right side of structure. Sedimentation above structure
Cattle path around edges of structure
Cattle path around left side of structure
Sedimentation and grass recruitment upstream of structure
Headcut upstream

Structure has side slope ORD "wings above upper pour over
Above stock pond. Upper reach of drainage includes Rd. 161

Structure built on top of previous structure built in 2008 that has been buried by sedimentation

Downstream splash pad well anchored. Placed at headcut which has vegetated over

Multiple layers of structure built after previous layer sedimented

Original ZB repaired in 2024
Appears repairs made after original structure eroded
Distance to road right side of structure : 62'
Close to road on valley right
ORD stabilizes 3 ZB
ORD stabilizes 3 ZB
ORD stabilizes 3 ZB
Wood racked on structure. Native boulder anchors structure valley right
Road immediately adjacent

Machine built
Machine built
Machine built

Machine Built

Armors outlet of 50 acre pond

Structure built too close to meander bend so more force was on one side of the structure causing erosion and dislodged rocks on river right of structure
Rock rundown entry tied into upstream entry 4’ long

Two tiered plunge pool built to match two tiered headcut
Machine built
Machine built. OED may have been built but buried.
Machine built.
Machine built
Machine built. Near roadway.
Submerged

Willow regeneration on banks. 75% sedimentation in channel up to structure height.
There is a rock run down on RL that feeds into ZB. Grass, Forbes, horsetail in ZB.
Horsetail filling in the structures
Some piping at bottom right of ZB below pour over key in.

Structure Type	Embeddedness (for One Rock Dam)	Other - Embeddedness (for One Rock Dam)	x	y
Zuni Bowl and One Rock Dam			-105.930514	35.6641179
Zuni Bowl			-105.9727933	35.68119967
Zuni Bowl and One Rock Dam			-106.3846128	35.07424159
Zuni Bowl and One Rock Dam			-106.3880057	35.0803199
Zuni Bowl and One Rock Dam			-106.387943	35.080503
Zuni Bowl and One Rock Dam			-106.385919	35.075038
One Rock Dam			-106.3832877	35.0704979
One Rock Dam			-106.3833383	35.0708986
One Rock Dam			-106.3832827	35.0713598
One Rock Dam			-106.386077	35.07598088
One Rock Dam			-106.3538823	35.0495828
One Rock Dam			-106.3538508	35.0495019
One Rock Dam			-106.3537596	35.049355
Zuni Bowl and One Rock Dam			-106.353654	35.049167
Zuni Bowl and One Rock Dam			-106.3536248	35.0490992
			-106.3535926	35.0490498
One Rock Dam			-106.3535139	35.048632
One Rock Dam			-106.3533556	35.0485077
Zuni Bowl and One Rock Dam			-106.3532121	35.0483469
Zuni Bowl and One Rock Dam			-106.3531756	35.0482939
One Rock Dam			-106.3529516	35.0481111
One Rock Dam			-106.3410934	35.01663208
One Rock Dam			-106.3386906	35.0170153
One Rock Dam			-106.338352	35.0171092
One Rock Dam			-106.338352	35.0171092
One Rock Dam			-106.3330915	35.0182646
One Rock Dam	Partially buried		-105.0615005	35.83273165
One Rock Dam	Partially buried		-105.0616055	35.83217267
One Rock Dam	Fully buried		-105.0623845	35.83162323
Zuni Bowl and One Rock Dam	Fully buried		-105.0626758	35.8308562
One Rock Dam	Gaps between rocks		-105.0625779	35.83105572
One Rock Dam	Gaps between rocks		-105.0609064	35.83294335
One Rock Dam	Partially buried		-105.0591178	35.82943648
One Rock Dam	Partially buried		-105.058157	35.8298955

Zuni Bowl and One Rock Dam	Partially buried	-105.0570489	35.83039503
Zuni Bowl		-105.0564703	35.83043095
One Rock Dam	Partially buried	-105.0739468	35.83258072
Zuni Bowl and One Rock Dam	Fully buried	-105.073796	35.83369238
One Rock Dam	Partially buried	-105.0738315	35.83372785
One Rock Dam	Partially buried	-105.0737952	35.83389832
One Rock Dam	Partially buried	-105.0745771	35.83710052
One Rock Dam	Partially buried	-105.0743599	35.83691543
One Rock Dam	Gaps between rocks	-105.0743866	35.83683278
One Rock Dam	Partially buried	-105.0742895	35.83600198
Zuni Bowl		-105.0949194	35.84008703
Zuni Bowl		-105.0948969	35.84017165
Zuni Bowl		-105.0933625	35.83949193
Zuni Bowl and One Rock Dam	Gaps between rocks	-105.0933022	35.83937163
Zuni Bowl and One Rock Dam	Partially buried	-105.09286	35.84709057
One Rock Dam	Partially buried	-106.6027886	35.92335123
Zuni Bowl		-106.6014258	35.9241155
Zuni Bowl and One Rock Dam		-106.6013747	35.9240822
Zuni Bowl and One Rock Dam		-106.6013722	35.9239816
Zuni Bowl and One Rock Dam		-106.6013507	35.92396522
One Rock Dam	Partially buried	-106.5974051	35.92597653
Zuni Bowl		-106.596739	35.92636523
Zuni Bowl		-106.5957161	35.9267053
One Rock Dam	Partially buried	-106.5956386	35.92677082
Zuni Bowl		-106.5953365	35.92701612
Zuni Bowl		-106.595385	35.92712025
Zuni Bowl		-106.5918327	35.93062668
Zuni Bowl and One Rock Dam	Fully buried	-106.5919297	35.93428847
Zuni Bowl and One Rock Dam		-106.5914269	35.93480662
Zuni Bowl and One Rock Dam	Partially buried	-106.588288	35.93802508
Zuni Bowl		-106.5883033	35.93793888
Zuni Bowl and One Rock Dam	Partially buried	-106.5808215	35.9372305
One Rock Dam	Partially buried	-106.5807458	35.93718655
One Rock Dam	Partially buried	-106.6111231	35.85977217
One Rock Dam	Partially buried	-106.6112377	35.85987838

One Rock Dam	Partially buried	-106.6112516	35.8599432
Zuni Bowl		-106.5157222	35.93745675
Zuni Bowl and One Rock Dam	Partially buried	-106.5162171	35.93705398
Zuni Bowl		-106.5159811	35.93712195
Zuni Bowl		-106.5071629	35.93253932
Zuni Bowl		-106.5069708	35.93246877
Zuni Bowl		-106.504073	35.93225377
Zuni Bowl and One Rock Dam	Partially buried	-106.5040297	35.93222283
Zuni Bowl		-106.5034389	35.93217562
Zuni Bowl and One Rock Dam	other	-106.5187872	35.8651939
Zuni Bowl and One Rock Dam	Partially buried	-106.5187878	35.86520847
Zuni Bowl and One Rock Dam	Partially buried	-105.9419599	35.44480557
Zuni Bowl and One Rock Dam	Partially buried	-105.9418646	35.44469897
Zuni Bowl and One Rock Dam	Partially buried	-105.9424022	35.44424813
Zuni Bowl and One Rock Dam	Partially buried	-105.9423819	35.44427455
Zuni Bowl and One Rock Dam	Partially buried	-105.9424171	35.44438518
Zuni Bowl and One Rock Dam	Partially buried	-105.942457	35.44432338
Zuni Bowl		-105.9429858	35.44385002
Zuni Bowl and One Rock Dam	Partially buried	-105.9428874	35.44374573
Zuni Bowl		-106.2243189	35.85993323
Zuni Bowl and One Rock Dam		-106.2243784	35.85996151
One Rock Dam		-106.2244515	35.86014432
One Rock Dam	Gaps between rocks	-105.9078511	36.18872842
One Rock Dam	Gaps between rocks	-105.9088917	36.18696822
Zuni Bowl and One Rock Dam	Partially buried	-105.9015625	36.18700093
Zuni Bowl and One Rock Dam	Partially buried	-105.892229	36.18216896
Zuni Bowl and One Rock Dam	Partially buried	-105.90233	36.184721
Zuni Bowl and One Rock Dam	Partially buried	-105.901541	36.18692301

Appendix C. Appendix C. Zuni Bowl Survey Report

NM DOT Zuni Bowl Survey

Submitted By: RioGrandeReturn1
Submitted Time: May 10, 2024 6:47 AM

Date and Time
April 19, 2024 1:31 PM

Surveyor Name
Abe Aufdermauer

Structure Identifier
SF Botanical Garden 10

Structure Type
Zuni Bowl and One Rock Dam

Location
-105.930514 35.6641179

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

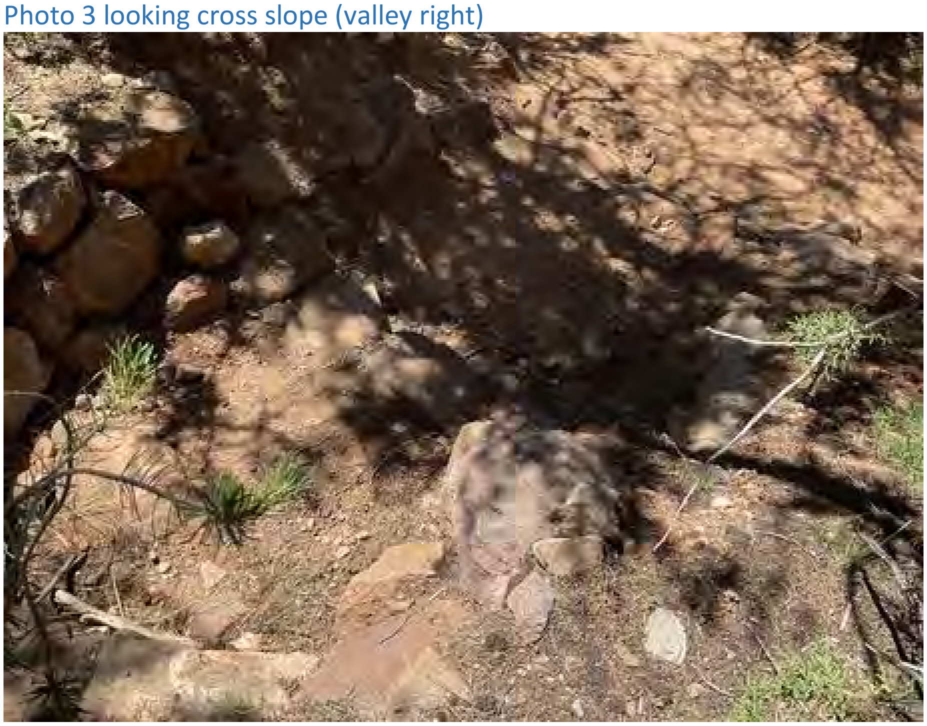

Photo 4 looking cross slope (valley left)

Condition
All rocks intact

Reason for Degraded Condition

Construction Material
Mixture of rock types

Additional information on Construction Material

Rock Angularity
Angular

Zuni Bowl Rock Size
6-12"

Zuni Bowl Length
3.75

Zuni Bowl Width
3.75

Zuni Bowl Height
.83

Lower Pour Over Height
0

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Buried

Embeddedness (for One Rock Dam)

Vegetation
Bare

Vegetation Type

One Rock Dam Rock Size
6-12"

One Rock Dam Length
1

One Rock Dam Width
5

One Rock Dam Height
0.5

Distance between Zuni Bowl and One Rock Dam
6.75

Age of Zuni Bowl/One Rock Dam

Difference between ZB and ORD Condition

Additional Notes
Rock appears to be locally sourced

NM DOT Zuni Bowl Survey
Submitted By: RioGrandeReturn1
Submitted Time: May 10, 2024 7:05 AM

Date and Time
April 19, 2024 2:34 PM

Surveyor Name
Abe Aufdermauer

Structure Identifier
Camino Rio

Structure Type
Zuni Bowl

Location
-105.9727933 35.68119967

Photo 1 looking upslope


Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Igneous

Additional information on Construction Material

Basalt

Rock Angularity

Round

Zuni Bowl Rock Size

25-36"

Zuni Bowl Length

10

Zuni Bowl Width

9.33

Zuni Bowl Height

1.75

Lower Pour Over Height
0.75

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Partially filled

Embeddedness (for One Rock Dam)

Vegetation
Bare

Vegetation Type

One Rock Dam Rock Size

One Rock Dam Length

One Rock Dam Width

One Rock Dam Height

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam

Difference between ZB and ORD Condition

Additional Notes
No ORD. Third in a series of ZBs on a steep slope. Imported rock used. Some small rock chinking (local material) is dislodged.

NM DOT Zuni Bowl Survey

Submitted By: RioGrandeReturn1

Submitted Time: May 14, 2024 6:28 PM

Date and Time

May 9, 2024 7:40 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Cedro Creek #1

Structure Type

Zuni Bowl and One Rock Dam

Location

-106.3846128 35.07424159

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Unknown

Construction Material

Sedimentary

Additional information on Construction Material

all limestone from roadway slope blast rock. Sourced from GCC aggregate plant

Rock Angularity
Mixed (some round, some angular)

Zuni Bowl Rock Size
13-18"

Zuni Bowl Length
12.4

Zuni Bowl Width
11.9

Zuni Bowl Height
1.5

Lower Pour Over Height
0.8

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
No additional sediment apparent

Embeddedness (for One Rock Dam)

Vegetation
1-25%

Vegetation Type
Grass

One Rock Dam Rock Size
6-12"

One Rock Dam Length
6

One Rock Dam Width
12.3

One Rock Dam Height
0.9

Distance between Zuni Bowl and One Rock Dam
6.9

Age of Zuni Bowl/One Rock Dam

2015

Difference between ZB and ORD Condition

Additional Notes

Elms growing throughout structure. Human trail on right bank may lead to future erosion. 30 feet from roadway above creek.

NM DOT Zuni Bowl Survey

Submitted By: RioGrandeReturn1

Submitted Time: May 14, 2024 6:28 PM

Date and Time

May 9, 2024 8:03 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Cedro Creek #2

Structure Type

Zuni Bowl and One Rock Dam

Location

-106.3880057 35.0803199

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

Some rocks dislodged or broken

Reason for Degraded Condition

Unknown

Construction Material

Sedimentary

Additional information on Construction Material

All limestone

Rock Angularity
Partially angular

Zuni Bowl Rock Size
19-24"

Zuni Bowl Length
10.1

Zuni Bowl Width
10

Zuni Bowl Height
2.2

Lower Pour Over Height
1.7

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
No additional sediment apparent

Embeddedness (for One Rock Dam)

Vegetation
51-75%

Vegetation Type
Mixture

One Rock Dam Rock Size
6-12"

One Rock Dam Length
7.5

One Rock Dam Width
12.6

One Rock Dam Height
0.5

Distance between Zuni Bowl and One Rock Dam
9.4

Age of Zuni Bowl/One Rock Dam

2015

Difference between ZB and ORD Condition

ORD is 5% intact. ZB is 95% intact

Additional Notes

ORD wing on left bank of ZB ties into edge of ZB

NM DOT Zuni Bowl Survey

Submitted By: RioGrandeReturn1

Submitted Time: May 14, 2024 6:29 PM

Date and Time

May 9, 2024 8:26 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Cedro Creek #3

Structure Type

Zuni Bowl and One Rock Dam

Location

-106.387943 35.080503

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition
Some rocks dislodged or broken

Reason for Degraded Condition

Construction Material
Sedimentary

Additional information on Construction Material
All limestone

Rock Angularity
Partially angular

Zuni Bowl Rock Size
Very large 5’ plus native rock used as basis for structure. Other rocks sedimented over

Zuni Bowl Length
14.6

Zuni Bowl Width
12.1

Zuni Bowl Height
1.4

Lower Pour Over Height
0.8

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Buried

Embeddedness (for One Rock Dam)

Vegetation
26-50%

Vegetation Type
Mixture

One Rock Dam Rock Size
6-12"

One Rock Dam Length
3.5

One Rock Dam Width
12

One Rock Dam Height
0.25

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2015

Difference between ZB and ORD Condition

Additional Notes
70% of structure sedimented

NM DOT Zuni Bowl Survey

Submitted By: RioGrandeReturn1

Submitted Time: May 14, 2024 6:29 PM

Date and Time

May 9, 2024 8:54 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Cedro Creek #8 ORD

Structure Type

Zuni Bowl and One Rock Dam

Location

-106.385919 35.075038

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)


Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Sedimentary

Additional information on Construction Material

Rock Angularity
Angular

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion

Sedimentation (for Zuni Bowl)

Embeddedness (for One Rock Dam)

Vegetation
76-100%

Vegetation Type
Grass

One Rock Dam Rock Size
13-18"

One Rock Dam Length
5.2

One Rock Dam Width
13.8

One Rock Dam Height
0.9

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2012

Difference between ZB and ORD Condition

Additional Notes

NM DOT Zuni Bowl Survey

Submitted By: RioGrandeReturn1

Submitted Time: May 14, 2024 6:30 PM

Date and Time

May 9, 2024 9:14 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Cedro Creek #7 ORD

Structure Type

One Rock Dam

Location

-106.3832877 35.0704979

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Sedimentary

Additional information on Construction Material

All limestone

Rock Angularity
Angular

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Buried

Embeddedness (for One Rock Dam)

Vegetation
76-100%

Vegetation Type
Grass

One Rock Dam Rock Size
19-24"

One Rock Dam Length
5.3

One Rock Dam Width
31.6

One Rock Dam Height
0.9

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2012

Difference between ZB and ORD Condition

Additional Notes
Ties to toe of slope of roadway captures roadway runoff. Break in road right of way armor

NM DOT Zuni Bowl Survey

Submitted By: RioGrandeReturn1

Submitted Time: May 14, 2024 6:31 PM

Date and Time

May 9, 2024 9:21 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Cedro Creek #6 ORD

Structure Type

One Rock Dam

Location

-106.3833383 35.0708986

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Sedimentary

Additional information on Construction Material

All limestone

Rock Angularity
Angular

Zuni Bowl Rock Size
6-12"

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Partially buried

Embeddedness (for One Rock Dam)

Vegetation
76-100%

Vegetation Type
Grass

One Rock Dam Rock Size
6-12"

One Rock Dam Length
9

One Rock Dam Width
27.3

One Rock Dam Height
1.2

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2012

Difference between ZB and ORD Condition

Additional Notes
Repair made second layer added upstream maybe 2015. Original rock 90% buried and vegetated

NM DOT Zuni Bowl Survey

Submitted By: RioGrandeReturn1

Submitted Time: May 14, 2024 6:31 PM

Date and Time

May 9, 2024 9:34 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Cedro Creek #5 ORD

Structure Type

One Rock Dam

Location

-106.3832827 35.0713598

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Sedimentary

Additional information on Construction Material

All limestone

Rock Angularity
Partially angular

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Buried

Embeddedness (for One Rock Dam)

Vegetation
76-100%

Vegetation Type
Grass

One Rock Dam Rock Size
6-12"

One Rock Dam Length
6.3

One Rock Dam Width
8.7

One Rock Dam Height
0.8

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2012

Difference between ZB and ORD Condition

Additional Notes
Second downstream layer added in 2015

NM DOT Zuni Bowl Survey

Submitted By: RioGrandeReturn1

Submitted Time: May 14, 2024 6:32 PM

Date and Time

May 9, 2024 9:46 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Cedro Creek #4 ORD

Structure Type

One Rock Dam

Location

-106.386077 35.07598088

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)


Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Sedimentary

Additional information on Construction Material

All limestone

Rock Angularity
Angular

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Partially buried

Embeddedness (for One Rock Dam)

Vegetation
76-100%

Vegetation Type
Mixture

One Rock Dam Rock Size
6-12"

One Rock Dam Length
6

One Rock Dam Width
12.4

One Rock Dam Height
1.2

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2012

Difference between ZB and ORD Condition

Additional Notes
Minor repair in 2015. Many elm saplings

NM DOT Zuni Bowl Survey

Submitted By: RioGrandeReturn1

Submitted Time: May 14, 2024 6:32 PM

Date and Time

May 9, 2024 10:30 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Juan Tomas #16 ORD

Structure Type

One Rock Dam

Location

-106.3538823 35.0495828

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Sedimentary

Additional information on Construction Material

All limestone imported

Rock Angularity
Partially angular

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
No additional sediment apparent

Embeddedness (for One Rock Dam)

Vegetation
Bare

Vegetation Type

One Rock Dam Rock Size
6-12"

One Rock Dam Length
7.8

One Rock Dam Width
21

One Rock Dam Height
1

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2024

Difference between ZB and ORD Condition

Additional Notes
Very recently built. 1st structure in drainage below forest road. Adjacent forest thinned/masticated. Increased erosion and sediment rate. At junction of FS252 and FS542

NM DOT Zuni Bowl Survey

Submitted By: RioGrandeReturn1

Submitted Time: May 14, 2024 6:33 PM

Date and Time

May 9, 2024 10:40 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Juan Tomas #15 ORD

Structure Type

One Rock Dam

Location

-106.3538508 35.0495019

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

Some rocks dislodged or broken

Reason for Degraded Condition

Unknown

Construction Material

Sedimentary

Additional information on Construction Material

All limestone imported

Rock Angularity
Angular

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Buried

Embeddedness (for One Rock Dam)

Vegetation
1-25%

Vegetation Type
Woody Vegetation

One Rock Dam Rock Size
13-18"

One Rock Dam Length
5.5

One Rock Dam Width
19.5

One Rock Dam Height
1

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2018

Difference between ZB and ORD Condition

Additional Notes
Roadway drainage

NM DOT Zuni Bowl Survey

Submitted By: RioGrandeReturn1

Submitted Time: May 14, 2024 6:33 PM

Date and Time

May 9, 2024 10:52 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Juan Tomas #14 ORD

Structure Type

One Rock Dam

Location

-106.3537596 35.049355

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Sedimentary

Additional information on Construction Material

All limestone imported

Rock Angularity
Angular

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Partially buried

Embeddedness (for One Rock Dam)

Vegetation
1-25%

Vegetation Type
Forbs

One Rock Dam Rock Size
6-12"

One Rock Dam Length
5

One Rock Dam Width
8.8

One Rock Dam Height
1.3

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2018

Difference between ZB and ORD Condition

Additional Notes

NM DOT Zuni Bowl Survey

Submitted By: RioGrandeReturn1

Submitted Time: May 14, 2024 6:34 PM

Date and Time

May 9, 2024 11:00 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Juan Tomas #13

Structure Type

Zuni Bowl and One Rock Dam

Location

-106.353654 35.049167

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Sedimentary

Additional information on Construction Material

All limestone imported

Rock Angularity
Mixed (some round, some angular)

Zuni Bowl Rock Size
6-12"

Zuni Bowl Length
5.5

Zuni Bowl Width
6.7

Zuni Bowl Height
0.9

Lower Pour Over Height
0.8

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Partially filled

Embeddedness (for One Rock Dam)

Vegetation
Bare

Vegetation Type

One Rock Dam Rock Size
13-18"

One Rock Dam Length
3.5

One Rock Dam Width
7

One Rock Dam Height
1

Distance between Zuni Bowl and One Rock Dam
3.5

Age of Zuni Bowl/One Rock Dam
2018

Difference between ZB and ORD Condition
ORD downstream edge erosion

Additional Notes
Very recent repair

NM DOT Zuni Bowl Survey

Submitted By: RioGrandeReturn1

Submitted Time: May 14, 2024 6:34 PM

Date and Time

May 9, 2024 11:42 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Juan Tomas #12 ORD

Structure Type

Zuni Bowl and One Rock Dam

Location

-106.3536248 35.0490992

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Sedimentary

Additional information on Construction Material

All limestone imported

Rock Angularity
Angular

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
No additional sediment apparent

Embeddedness (for One Rock Dam)

Vegetation
Bare

Vegetation Type

One Rock Dam Rock Size
6-12"

One Rock Dam Length
6

One Rock Dam Width
9.5

One Rock Dam Height
1.3

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2024

Difference between ZB and ORD Condition

Additional Notes
Recently built roadway drainage

NM DOT Zuni Bowl Survey

Submitted By: RioGrandeReturn1

Submitted Time: May 14, 2024 6:35 PM

Date and Time

May 9, 2024 11:48 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Juan Tomas #11 drop inlet

Structure Type

Location

-106.3535926 35.0490498

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Sedimentary

Additional information on Construction Material

Limestone and some sandstone some rock local

Rock Angularity
Angular

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Partially filled

Embeddedness (for One Rock Dam)

Vegetation
Bare

Vegetation Type

One Rock Dam Rock Size

One Rock Dam Length

One Rock Dam Width

One Rock Dam Height

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2018

Difference between ZB and ORD Condition

Additional Notes
30” oval flat bottom corrugated steel culvert

NM DOT Zuni Bowl Survey

Submitted By: RioGrandeReturn1

Submitted Time: May 14, 2024 6:35 PM

Date and Time

May 9, 2024 11:56 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Juan Tomas #10 ORD

Structure Type

One Rock Dam

Location

-106.3535139 35.048632

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Sedimentary

Additional information on Construction Material

All limestone imported

Rock Angularity
Angular

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Partially filled

Embeddedness (for One Rock Dam)

Vegetation
1-25%

Vegetation Type
Grass

One Rock Dam Rock Size
6-12"

One Rock Dam Length
2.6

One Rock Dam Width
5

One Rock Dam Height
0.8

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2018

Difference between ZB and ORD Condition

Additional Notes
Two lobed head cut immediately upstream

NM DOT Zuni Bowl Survey

Submitted By: RioGrandeReturn1

Submitted Time: May 14, 2024 6:36 PM

Date and Time

May 9, 2024 12:01 PM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Juan Tomas #9 ORD

Structure Type

One Rock Dam

Location

-106.3533556 35.0485077

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Sedimentary

Additional information on Construction Material

All imported limestone

Rock Angularity
Angular

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Partially buried

Embeddedness (for One Rock Dam)

Vegetation
26-50%

Vegetation Type
Mixture

One Rock Dam Rock Size
6-12"

One Rock Dam Length
4

One Rock Dam Width
5

One Rock Dam Height
0.7

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2018

Difference between ZB and ORD Condition

Additional Notes

NM DOT Zuni Bowl Survey

Submitted By: RioGrandeReturn1

Submitted Time: May 14, 2024 6:36 PM

Date and Time

May 9, 2024 12:08 PM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Juan Tomas #8

Structure Type

Zuni Bowl and One Rock Dam

Location

-106.3532121 35.0483469

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

Some rocks dislodged or broken

Reason for Degraded Condition

Unknown

Construction Material

Sedimentary

Additional information on Construction Material

All imported limestone

Rock Angularity
Angular

Zuni Bowl Rock Size
6-12"

Zuni Bowl Length
7.3

Zuni Bowl Width
6.5

Zuni Bowl Height
1.5

Lower Pour Over Height
0.6

Erosion
Erosion around sides

Sedimentation (for Zuni Bowl)
Partially buried

Embeddedness (for One Rock Dam)

Vegetation
1-25%

Vegetation Type
Mixture

One Rock Dam Rock Size
6-12"

One Rock Dam Length
4.6

One Rock Dam Width
3

One Rock Dam Height
0.2

Distance between Zuni Bowl and One Rock Dam
0.5

Age of Zuni Bowl/One Rock Dam

2018

Difference between ZB and ORD Condition

Additional Notes

NM DOT Zuni Bowl Survey

Submitted By: RioGrandeReturn1

Submitted Time: May 14, 2024 6:37 PM

Date and Time

May 9, 2024 12:22 PM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Juan Tomas #7 ORD

Structure Type

Zuni Bowl and One Rock Dam

Location

-106.3531756 35.0482939

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Sedimentary

Additional information on Construction Material

All imported limestone

Rock Angularity
Angular

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion
Erosion around sides

Sedimentation (for Zuni Bowl)
Buried

Embeddedness (for One Rock Dam)

Vegetation
26-50%

Vegetation Type
Grass

One Rock Dam Rock Size
6-12"

One Rock Dam Length
6

One Rock Dam Width
7.5

One Rock Dam Height
0.9

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2018

Difference between ZB and ORD Condition

Additional Notes

NM DOT Zuni Bowl Survey

Submitted By: RioGrandeReturn1

Submitted Time: May 14, 2024 6:37 PM

Date and Time

May 9, 2024 12:23 PM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Juan Tomas #6

Structure Type

One Rock Dam

Location

-106.3529516 35.0481111

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Sedimentary

Additional information on Construction Material

All imported limestone

Rock Angularity
Angular

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Partially filled

Embeddedness (for One Rock Dam)

Vegetation
1-25%

Vegetation Type
Mixture

One Rock Dam Rock Size
6-12"

One Rock Dam Length
9

One Rock Dam Width
6

One Rock Dam Height
0.9

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2018

Difference between ZB and ORD Condition

Additional Notes

NM DOT Zuni Bowl Survey
Submitted By: RioGrandeReturn1
Submitted Time: May 14, 2024 6:37 PM

Date and Time
May 9, 2024 1:40 PM

Surveyor Name
Abe Aufdermauer

Structure Identifier
Pine Flats North #1 ORD

Structure Type
One Rock Dam

Location
-106.3410934 35.01663208

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Sedimentary

Additional information on Construction Material

Native limestone

Rock Angularity
Angular

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Buried

Embeddedness (for One Rock Dam)

Vegetation
1-25%

Vegetation Type
Forbs

One Rock Dam Rock Size
13-18"

One Rock Dam Length
6.4

One Rock Dam Width
21.3

One Rock Dam Height
2

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam

2018

Difference between ZB and ORD Condition

Additional Notes

100 ft upstream of 5’ flat bottom culvert

NM DOT Zuni Bowl Survey

Submitted By: RioGrandeReturn1

Submitted Time: May 14, 2024 6:38 PM

Date and Time

May 9, 2024 1:53 PM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Pine Flat North #2 ORD

Structure Type

One Rock Dam

Location

-106.3386906 35.0170153

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Sedimentary

Additional information on Construction Material

All native limestone

Rock Angularity
Angular

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Partially filled

Embeddedness (for One Rock Dam)

Vegetation
1-25%

Vegetation Type
Mixture

One Rock Dam Rock Size
6-12"

One Rock Dam Length
7

One Rock Dam Width
10

One Rock Dam Height
12

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2018

Difference between ZB and ORD Condition

Additional Notes
Large front rocks filled behind with smaller rocks

NM DOT Zuni Bowl Survey

Submitted By: RioGrandeReturn1

Submitted Time: May 14, 2024 6:38 PM

Date and Time

May 9, 2024 2:08 PM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Pine Flat #3

Structure Type

One Rock Dam

Location

-106.338352 35.0171092

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Sedimentary

Additional information on Construction Material

Native limestone

Rock Angularity
Angular

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Partially buried

Embeddedness (for One Rock Dam)

Vegetation
Bare

Vegetation Type

One Rock Dam Rock Size
6-12"

One Rock Dam Length
8

One Rock Dam Width
14.7

One Rock Dam Height
1.5

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2018

Difference between ZB and ORD Condition

Additional Notes
Built onto bedrock

NM DOT Zuni Bowl Survey

Submitted By: RioGrandeReturn1

Submitted Time: May 14, 2024 6:39 PM

Date and Time

May 9, 2024 2:17 PM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Pine Flat North #4 ORD

Structure Type

One Rock Dam

Location

-106.338352 35.0171092

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Sedimentary

Additional information on Construction Material

Native limestone and sandstone

Rock Angularity
Partially angular

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Partially buried

Embeddedness (for One Rock Dam)

Vegetation
Bare

Vegetation Type

One Rock Dam Rock Size
6-12"

One Rock Dam Length
6

One Rock Dam Width
9

One Rock Dam Height
0.8

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2018

Difference between ZB and ORD Condition

Additional Notes

NM DOT Zuni Bowl Survey

Submitted By: RioGrandeReturn1

Submitted Time: May 14, 2024 6:39 PM

Date and Time

May 9, 2024 2:28 PM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Pine Flat #5 ORD

Structure Type

One Rock Dam

Location

-106.3330915 35.0182646

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

Some rocks dislodged or broken

Reason for Degraded Condition

Human interference (vehicles or foot traffic)

Construction Material

Sedimentary

Additional information on Construction Material

Native limestone and sandstone

Rock Angularity
Partially angular

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Partially filled

Embeddedness (for One Rock Dam)

Vegetation
1-25%

Vegetation Type
Forbs

One Rock Dam Rock Size
6-12"

One Rock Dam Length
5.8

One Rock Dam Width
10

One Rock Dam Height
0.6

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam

2018

Difference between ZB and ORD Condition

Additional Notes

Mountain bike trail through middle of structure dislodged rocks

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 14, 2024 7:08 PM

Date and Time

May 19, 2024 8:47 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Rio Mora NWR #10

Structure Type

One Rock Dam

Location

-105.0615005 35.83273165

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Sedimentary

Additional information on Construction Material

Native sandstone

Rock Angularity
Partially angular

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion
No new erosion

Sedimentation (for Zuni Bowl)

Embeddedness (for One Rock Dam)
Partially buried

Vegetation
51-75%

Vegetation Type
Mixture

One Rock Dam Rock Size
6-12"

One Rock Dam Length
6

One Rock Dam Width
19.5

One Rock Dam Height
0.5

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam

Difference between ZB and ORD Condition

Additional Notes

Old road crossing directly above the structure sedimenting due to ORD grade control

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 14, 2024 7:09 PM

Date and Time

May 19, 2024 8:56 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Rio Mora NWR #9

Structure Type

One Rock Dam

Location

-105.0616055 35.83217267

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition
Some rocks dislodged or broken

Reason for Degraded Condition
Dislodged by water

Construction Material
Sedimentary

Additional information on Construction Material
Native sandstone

Rock Angularity
Partially angular

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion
No new erosion

Sedimentation (for Zuni Bowl)

Embeddedness (for One Rock Dam)
Partially buried

Vegetation
26-50%

Vegetation Type
Mixture

One Rock Dam Rock Size
6-12"

One Rock Dam Length
7

One Rock Dam Width
18

One Rock Dam Height
0.3

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam

Difference between ZB and ORD Condition

Additional Notes

Old road crossing of arroyo above the structure. Willow recruitment in structure and captured sediment upstream. Rocks dislodged in thalweg along length

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 14, 2024 7:09 PM

Date and Time

May 19, 2024 9:06 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Rio Mora NWR #8

Structure Type

One Rock Dam

Location

-105.0623845 35.83162323

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Sedimentary

Additional information on Construction Material

Native sandstone

Rock Angularity
Partially angular

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion

Sedimentation (for Zuni Bowl)

Embeddedness (for One Rock Dam)
Fully buried

Vegetation
76-100%

Vegetation Type
Grass

One Rock Dam Rock Size
13-18"

One Rock Dam Length
9

One Rock Dam Width
15

One Rock Dam Height
1.4

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam

Difference between ZB and ORD Condition

Additional Notes

Pedestrian or cattle path around right side of structure. Sedimentation above structure

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 14, 2024 7:10 PM

Date and Time

May 19, 2024 9:24 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Rio Mora NWR #7

Structure Type

Zuni Bowl and One Rock Dam

Location

-105.0626758 35.8308562

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

Some rocks dislodged or broken

Reason for Degraded Condition

Dislodged by water

Construction Material

Sedimentary

Additional information on Construction Material

Native rock

Rock Angularity
Partially angular

Zuni Bowl Rock Size
6-12"

Zuni Bowl Length
4

Zuni Bowl Width
6

Zuni Bowl Height
1.3

Lower Pour Over Height
0.9

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Partially filled

Embeddedness (for One Rock Dam)
Fully buried

Vegetation
51-75%

Vegetation Type
Mixture

One Rock Dam Rock Size
13-18"

One Rock Dam Length
5

One Rock Dam Width
12

One Rock Dam Height
0.6

Distance between Zuni Bowl and One Rock Dam
7.5

Age of Zuni Bowl/One Rock Dam

Difference between ZB and ORD Condition

Some rocks dislodged in ZB and less vegetated

Additional Notes

Cattle path around edges of structure

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 14, 2024 7:10 PM

Date and Time

May 19, 2024 9:36 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Rio Mora NWR #6

Structure Type

One Rock Dam

Location

-105.0625779 35.83105572

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Sedimentary

Additional information on Construction Material

Native sandstone

Rock Angularity
Partially angular

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion
Erosion around sides

Sedimentation (for Zuni Bowl)

Embeddedness (for One Rock Dam)
Gaps between rocks

Vegetation
26-50%

Vegetation Type
Grass

One Rock Dam Rock Size
13-18"

One Rock Dam Length
7.2

One Rock Dam Width
15.1

One Rock Dam Height
1.1

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam

Difference between ZB and ORD Condition

Additional Notes

Cattle path around left side of structure

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 14, 2024 7:11 PM

Date and Time

May 19, 2024 9:52 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Rio Mora NWR #5

Structure Type

One Rock Dam

Location

-105.0609064 35.83294335

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

Some rocks dislodged or broken

Reason for Degraded Condition

Dislodged by water

Construction Material

Sedimentary

Additional information on Construction Material

Native sandstone

Rock Angularity
Angular

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion
No new erosion

Sedimentation (for Zuni Bowl)

Embeddedness (for One Rock Dam)
Gaps between rocks

Vegetation
26-50%

Vegetation Type
Grass

One Rock Dam Rock Size
6-12"

One Rock Dam Length
7

One Rock Dam Width
19.5

One Rock Dam Height
2

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam

Difference between ZB and ORD Condition

Additional Notes

Sedimentation and grass recruitment upstream of structure

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 14, 2024 7:11 PM

Date and Time

May 19, 2024 10:00 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Rio Mora NWR #4

Structure Type

One Rock Dam

Location

-105.0591178   35.82943648

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Sedimentary

Additional information on Construction Material

Native sandstone

Rock Angularity
Angular

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion
No new erosion

Sedimentation (for Zuni Bowl)

Embeddedness (for One Rock Dam)
Partially buried

Vegetation
76-100%

Vegetation Type
Grass

One Rock Dam Rock Size
13-18"

One Rock Dam Length
6

One Rock Dam Width
22

One Rock Dam Height
0.2

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam

Difference between ZB and ORD Condition

Additional Notes

Headcut upstream

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 14, 2024 7:12 PM

Date and Time

May 19, 2024 10:07 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Rio Mora NWR #3

Structure Type

One Rock Dam

Location

-105.058157 35.8298955

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Sedimentary

Additional information on Construction Material

Native sandstone

Rock Angularity
Partially angular

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion
No new erosion

Sedimentation (for Zuni Bowl)

Embeddedness (for One Rock Dam)
Partially buried

Vegetation
26-50%

Vegetation Type
Grass

One Rock Dam Rock Size
13-18"

One Rock Dam Length
5.5

One Rock Dam Width
16

One Rock Dam Height
1.3

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam

Difference between ZB and ORD Condition

Additional Notes

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 14, 2024 7:12 PM

Date and Time

May 19, 2024 10:13 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Rio Mora NWR #2

Structure Type

Zuni Bowl and One Rock Dam

Location

-105.0570489 35.83039503

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Sedimentary

Additional information on Construction Material

Native sandstone

Rock Angularity
Partially angular

Zuni Bowl Rock Size
6-12"

Zuni Bowl Length
8

Zuni Bowl Width
6

Zuni Bowl Height
2.1

Lower Pour Over Height
0.8

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
No additional sediment apparent

Embeddedness (for One Rock Dam)
Partially buried

Vegetation
26-50%

Vegetation Type
Mixture

One Rock Dam Rock Size
6-12"

One Rock Dam Length
5.5

One Rock Dam Width
13

One Rock Dam Height
1

Distance between Zuni Bowl and One Rock Dam
20

Age of Zuni Bowl/One Rock Dam

Difference between ZB and ORD Condition

Additional Notes

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 14, 2024 7:12 PM

Date and Time

May 19, 2024 10:26 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Rio Mora NWR #1

Structure Type

Zuni Bowl

Location

-105.0564703 35.83043095

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition
All rocks intact

Reason for Degraded Condition

Construction Material
Sedimentary

Additional information on Construction Material
Native sandstone

Rock Angularity
Mixed (some round, some angular)

Zuni Bowl Rock Size
6-12"

Zuni Bowl Length
22

Zuni Bowl Width
20.5

Zuni Bowl Height
3.6

Lower Pour Over Height
0.9

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Partially buried

Embeddedness (for One Rock Dam)

Vegetation
26-50%

Vegetation Type
Grass

One Rock Dam Rock Size

One Rock Dam Length

One Rock Dam Width

One Rock Dam Height

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam

Difference between ZB and ORD Condition

Additional Notes

Structure has side slope ORD “wings above upper pour over

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 14, 2024 7:13 PM

Date and Time

May 19, 2024 11:21 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Rio Mora NWR #11

Structure Type

One Rock Dam

Location

-105.0739468 35.83258072

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Sedimentary

Additional information on Construction Material

Native sandstone

Rock Angularity
Mixed (some round, some angular)

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion
No new erosion

Sedimentation (for Zuni Bowl)

Embeddedness (for One Rock Dam)
Partially buried

Vegetation
76-100%

Vegetation Type
Mixture

One Rock Dam Rock Size
6-12"

One Rock Dam Length
6.1

One Rock Dam Width
21

One Rock Dam Height
0.6

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2008

Difference between ZB and ORD Condition

Additional Notes
Above stock pond. Upper reach of drainage includes Rd. 161

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 14, 2024 7:13 PM

Date and Time

May 19, 2024 11:42 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Rio Mora NWR #12

Structure Type

Zuni Bowl and One Rock Dam

Location

-105.073796 35.83369238

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Sedimentary

Additional information on Construction Material

All native limestone

Rock Angularity
Mixed (some round, some angular)

Zuni Bowl Rock Size
6-12"

Zuni Bowl Length
7

Zuni Bowl Width
8

Zuni Bowl Height
1.1

Lower Pour Over Height
0.9

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Partially buried

Embeddedness (for One Rock Dam)
Fully buried

Vegetation
76-100%

Vegetation Type
Mixture

One Rock Dam Rock Size
6-12"

One Rock Dam Length
2.5

One Rock Dam Width
10

One Rock Dam Height
1

Distance between Zuni Bowl and One Rock Dam
8.1

Age of Zuni Bowl/One Rock Dam
2008

Difference between ZB and ORD Condition
ORD buried and willow recruitment

Additional Notes

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 14, 2024 7:14 PM

Date and Time

May 19, 2024 11:51 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Rio Mora NWR. #13

Structure Type

One Rock Dam

Location

-105.0738315 35.83372785

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Sedimentary

Additional information on Construction Material

All native sandstone

Rock Angularity
Partially angular

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion
No new erosion

Sedimentation (for Zuni Bowl)

Embeddedness (for One Rock Dam)
Partially buried

Vegetation
76-100%

Vegetation Type
Woody Vegetation

One Rock Dam Rock Size
13-18"

One Rock Dam Length
7.3

One Rock Dam Width
18

One Rock Dam Height
1.2

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2008

Difference between ZB and ORD Condition

Additional Notes

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 14, 2024 7:14 PM

Date and Time

May 19, 2024 11:58 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Rio Mora NWR #14

Structure Type

One Rock Dam

Location

-105.0737952 35.83389832

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Sedimentary

Additional information on Construction Material

All native sandstone with some limestone

Rock Angularity
Partially angular

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion
No new erosion

Sedimentation (for Zuni Bowl)

Embeddedness (for One Rock Dam)
Partially buried

Vegetation
76-100%

Vegetation Type
Woody Vegetation

One Rock Dam Rock Size
6-12"

One Rock Dam Length
5

One Rock Dam Width
20

One Rock Dam Height
0.8

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2010

Difference between ZB and ORD Condition

Additional Notes
Structure built on top of previous structure built in 2008 that has been buried by sedimentation

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 14, 2024 7:14 PM

Date and Time

May 19, 2024 12:10 PM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Rio Mora NWR #15

Structure Type

One Rock Dam

Location

-105.0745771 35.83710052

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Sedimentary

Additional information on Construction Material

All native sandstone

Rock Angularity
Angular

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion
No new erosion

Sedimentation (for Zuni Bowl)

Embeddedness (for One Rock Dam)
Partially buried

Vegetation
51-75%

Vegetation Type
Woody Vegetation

One Rock Dam Rock Size
13-18"

One Rock Dam Length
6

One Rock Dam Width
12

One Rock Dam Height
1.2

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam

2010

Difference between ZB and ORD Condition

Additional Notes

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 14, 2024 7:15 PM

Date and Time

May 19, 2024 12:19 PM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Rio Mora NWR #16

Structure Type

One Rock Dam

Location

-105.0743599 35.83691543

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Sedimentary

Additional information on Construction Material

All native sandstone

Rock Angularity
Partially angular

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion
No new erosion

Sedimentation (for Zuni Bowl)

Embeddedness (for One Rock Dam)
Partially buried

Vegetation
76-100%

Vegetation Type
Grass

One Rock Dam Rock Size
6-12"

One Rock Dam Length
7.4

One Rock Dam Width
11.5

One Rock Dam Height
0.8

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2010

Difference between ZB and ORD Condition

Additional Notes
Downstream splash pad well anchored. Placed at headcut which has vegetated over

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 14, 2024 7:15 PM

Date and Time

May 19, 2024 12:24 PM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Rio Mora NWR #17

Structure Type

One Rock Dam

Location

-105.0743866 35.83683278

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Sedimentary

Additional information on Construction Material

All native sandstone

Rock Angularity
Angular

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion
No new erosion

Sedimentation (for Zuni Bowl)

Embeddedness (for One Rock Dam)
Gaps between rocks

Vegetation
76-100%

Vegetation Type
Grass

One Rock Dam Rock Size
6-12"

One Rock Dam Length
12.5

One Rock Dam Width
13

One Rock Dam Height
1

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam

2010

Difference between ZB and ORD Condition

Additional Notes

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 14, 2024 7:15 PM

Date and Time

May 19, 2024 12:30 PM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Rio Mora NWR #18

Structure Type

One Rock Dam

Location

-105.0742895 35.83600198

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

Some rocks dislodged or broken

Reason for Degraded Condition

Dislodged by water

Construction Material

Sedimentary

Additional information on Construction Material

Native sandstone

Rock Angularity

Mixed (some round, some angular)

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion

No new erosion

Sedimentation (for Zuni Bowl)

Embeddedness (for One Rock Dam)

Partially buried

Vegetation

76-100%

Vegetation Type

Woody Vegetation

One Rock Dam Rock Size

6-12"

One Rock Dam Length

14

One Rock Dam Width

18

One Rock Dam Height

0.5

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2010

Difference between ZB and ORD Condition

Additional Notes
Multiple layers of structure built after previous layer sedimented

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 14, 2024 7:16 PM

Date and Time

May 19, 2024 1:47 PM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Rio Mora NWR #19

Structure Type

Zuni Bowl

Location

-105.0949194 35.84008703

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Sedimentary

Additional information on Construction Material

Sandstone

Rock Angularity
Angular

Zuni Bowl Rock Size
6-12"

Zuni Bowl Length
11

Zuni Bowl Width
11

Zuni Bowl Height
1.4

Lower Pour Over Height
0.2

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Partially filled

Embeddedness (for One Rock Dam)

Vegetation
26-50%

Vegetation Type
Grass

One Rock Dam Rock Size

One Rock Dam Length

One Rock Dam Width

One Rock Dam Height

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam

2021

Difference between ZB and ORD Condition

Additional Notes

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 14, 2024 7:16 PM

Date and Time

May 19, 2024 1:55 PM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Rio Mora NWR #20

Structure Type

Zuni Bowl

Location

-105.0948969 35.84017165

Photo 1 looking upslope

Photo 2 looking downslope


Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition
All rocks intact

Reason for Degraded Condition

Construction Material
Sedimentary

Additional information on Construction Material
All sandstone

Rock Angularity
Angular

Zuni Bowl Rock Size
6-12"

Zuni Bowl Length
8.5

Zuni Bowl Width
10

Zuni Bowl Height
2.1

Lower Pour Over Height
0.8

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
No additional sediment apparent

Embeddedness (for One Rock Dam)

Vegetation
76-100%

Vegetation Type
Grass

One Rock Dam Rock Size

One Rock Dam Length

One Rock Dam Width

One Rock Dam Height

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam

Difference between ZB and ORD Condition

Additional Notes

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 14, 2024 7:16 PM

Date and Time

May 19, 2024 2:13 PM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Rio Mora NWR #21

Structure Type

Zuni Bowl

Location

-105.0933625 35.83949193

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Sedimentary

Additional information on Construction Material

All sandstone

Rock Angularity
Mixed (some round, some angular)

Zuni Bowl Rock Size
6-12"

Zuni Bowl Length
15

Zuni Bowl Width
16

Zuni Bowl Height
2.5

Lower Pour Over Height
0.5

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Partially filled

Embeddedness (for One Rock Dam)

Vegetation
26-50%

Vegetation Type
Forbs

One Rock Dam Rock Size

One Rock Dam Length

One Rock Dam Width

One Rock Dam Height

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam

Difference between ZB and ORD Condition

Additional Notes

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 14, 2024 7:17 PM

Date and Time

May 19, 2024 2:13 PM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Rio Mora NWR #22

Structure Type

Zuni Bowl and One Rock Dam

Location

-105.0933022 35.83937163

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

Some rocks dislodged or broken

Reason for Degraded Condition

Unknown

Construction Material

Sedimentary

Additional information on Construction Material

Mostly sandstone some limestone

Rock Angularity
Mixed (some round, some angular)

Zuni Bowl Rock Size
6-12"

Zuni Bowl Length
13

Zuni Bowl Width
12

Zuni Bowl Height
3.5

Lower Pour Over Height
1

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Partially filled

Embeddedness (for One Rock Dam)
Gaps between rocks

Vegetation
1-25%

Vegetation Type
Forbs

One Rock Dam Rock Size
6-12"

One Rock Dam Length
5.9

One Rock Dam Width
5.6

One Rock Dam Height
0.8

Distance between Zuni Bowl and One Rock Dam
15

Age of Zuni Bowl/One Rock Dam
2024

Difference between ZB and ORD Condition

Additional Notes
Original ZB repaired in 2024

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 14, 2024 7:17 PM

Date and Time

May 19, 2024 2:36 PM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Rio Mora NWR #23

Structure Type

Zuni Bowl and One Rock Dam

Location

-105.09286 35.84709057

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

Some rocks dislodged or broken

Reason for Degraded Condition

Dislodged by water

Construction Material

Sedimentary

Additional information on Construction Material

Mostly sandstone some limestone

Rock Angularity
Partially angular

Zuni Bowl Rock Size
6-12"

Zuni Bowl Length
15

Zuni Bowl Width
10

Zuni Bowl Height
3.1

Lower Pour Over Height
1

Erosion
Erosion around sides

Sedimentation (for Zuni Bowl)
Partially filled

Embeddedness (for One Rock Dam)
Partially buried

Vegetation
26-50%

Vegetation Type
Forbs

One Rock Dam Rock Size
6-12"

One Rock Dam Length
3.5

One Rock Dam Width
9

One Rock Dam Height
0.8

Distance between Zuni Bowl and One Rock Dam
17

Age of Zuni Bowl/One Rock Dam

Difference between ZB and ORD Condition

Additional Notes

Appears repairs made after original structure eroded

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 19, 2024 3:31 PM

Date and Time

July 16, 2024 8:30 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Sulphur Creek #1

Structure Type

One Rock Dam

Location

-106.6027886 35.92335123

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Igneous

Additional information on Construction Material

Rock Angularity
Angular

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion
Undercutting

Sedimentation (for Zuni Bowl)

Embeddedness (for One Rock Dam)
Partially buried

Vegetation
76-100%

Vegetation Type
Mixture

One Rock Dam Rock Size
6-12"

One Rock Dam Length
7.3

One Rock Dam Width
4.4

One Rock Dam Height
2.7

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2017

Difference between ZB and ORD Condition

Additional Notes
Distance to road right side of structure : 62’

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 19, 2024 3:31 PM

Date and Time

July 16, 2024 8:48 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Sulphur Creek #2

Structure Type

Zuni Bowl

Location

-106.6014258 35.9241155

Photo 1 looking upslope

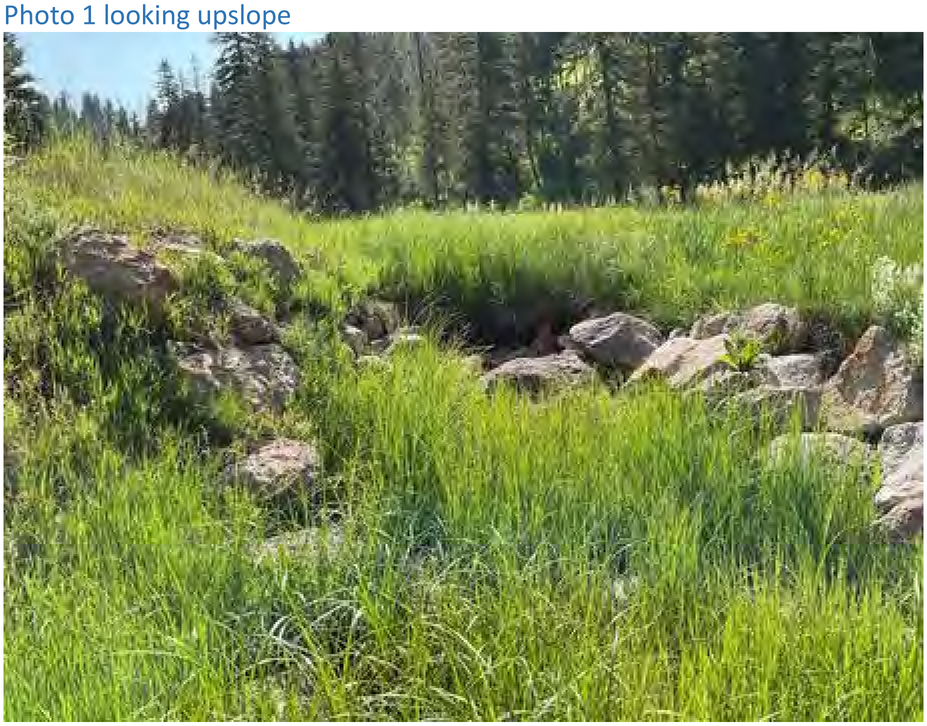

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition
Some rocks dislodged or broken

Reason for Degraded Condition
Dislodged by water

Construction Material
Igneous

Additional information on Construction Material

Rock Angularity
Partially angular

Zuni Bowl Rock Size
19-24"

Zuni Bowl Length
18.3

Zuni Bowl Width
16.4

Zuni Bowl Height
3.4

Lower Pour Over Height
1.3

Erosion
Undercutting

Sedimentation (for Zuni Bowl)
Partially filled

Embeddedness (for One Rock Dam)

Vegetation
51-75%

Vegetation Type
Grass

One Rock Dam Rock Size

One Rock Dam Length

One Rock Dam Width

One Rock Dam Height

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2017

Difference between ZB and ORD Condition

Additional Notes
Close to road on valley right

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 19, 2024 3:31 PM

Date and Time

July 16, 2024 9:05 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Sulphur Creek #3

Structure Type

Zuni Bowl and One Rock Dam

Location

-106.6013747 35.9240822

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Igneous

Additional information on Construction Material

Rock Angularity
Partially angular

Zuni Bowl Rock Size
6-12"

Zuni Bowl Length
6.1

Zuni Bowl Width
5.9

Zuni Bowl Height
1.3

Lower Pour Over Height
0.3

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Partially buried

Embeddedness (for One Rock Dam)

Vegetation
76-100%

Vegetation Type
Mixture

One Rock Dam Rock Size
6-12"

One Rock Dam Length
6.5

One Rock Dam Width
10.9

One Rock Dam Height
1.3

Distance between Zuni Bowl and One Rock Dam
6.6

Age of Zuni Bowl/One Rock Dam
2017

Difference between ZB and ORD Condition

Additional Notes
ORD stabilizes 3 ZB

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 19, 2024 3:32 PM

Date and Time

July 16, 2024 9:20 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Sulphur Creek #4

Structure Type

Zuni Bowl and One Rock Dam

Location

-106.6013722 35.9239816

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

Some rocks dislodged or broken

Reason for Degraded Condition

Dislodged by water

Construction Material

Igneous

Additional information on Construction Material

Rock Angularity
Partially angular

Zuni Bowl Rock Size
6-12"

Zuni Bowl Length
8.3

Zuni Bowl Width
8

Zuni Bowl Height
1.3

Lower Pour Over Height
0.1

Erosion
Undercutting

Sedimentation (for Zuni Bowl)
Partially filled

Embeddedness (for One Rock Dam)

Vegetation
76-100%

Vegetation Type
Mixture

One Rock Dam Rock Size
6-12"

One Rock Dam Length
6.5

One Rock Dam Width
10.9

One Rock Dam Height
1.3

Distance between Zuni Bowl and One Rock Dam
3.7

Age of Zuni Bowl/One Rock Dam
2017

Difference between ZB and ORD Condition

Additional Notes
ORD stabilizes 3 ZB

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 19, 2024 3:32 PM

Date and Time

July 16, 2024 9:26 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Sulphur Creek #5

Structure Type

Zuni Bowl and One Rock Dam

Location

-106.6013507 35.92396522

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

Some rocks dislodged or broken

Reason for Degraded Condition

Dislodged by water

Construction Material

Igneous

Additional information on Construction Material

Rock Angularity
Angular

Zuni Bowl Rock Size
6-12"

Zuni Bowl Length
6

Zuni Bowl Width
10

Zuni Bowl Height
2.8

Lower Pour Over Height
0.6

Erosion
Undercutting

Sedimentation (for Zuni Bowl)
Partially filled

Embeddedness (for One Rock Dam)

Vegetation
76-100%

Vegetation Type
Mixture

One Rock Dam Rock Size
6-12"

One Rock Dam Length
6.5

One Rock Dam Width
10.9

One Rock Dam Height
1.3

Distance between Zuni Bowl and One Rock Dam
6.8

Age of Zuni Bowl/One Rock Dam
2017

Difference between ZB and ORD Condition

Additional Notes
ORD stabilizes 3 ZB

NM DOT Zuni Bowl Survey
Submitted By: Anonymous user
Submitted Time: July 19, 2024 3:32 PM

Date and Time
July 16, 2024 9:40 AM

Surveyor Name
Abe Aufdermauer

Structure Identifier
Sulphur Creek #6

Structure Type
One Rock Dam

Location
-106.5974051 35.92597653

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Igneous

Additional information on Construction Material

Rock Angularity
Partially angular

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion
No new erosion

Sedimentation (for Zuni Bowl)

Embeddedness (for One Rock Dam)
Partially buried

Vegetation
26-50%

Vegetation Type
Mixture

One Rock Dam Rock Size
13-18"

One Rock Dam Length
6.7

One Rock Dam Width
18.5

One Rock Dam Height
1

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2017

Difference between ZB and ORD Condition

Additional Notes
Wood racked on structure. Native boulder anchors structure valley right

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 19, 2024 3:33 PM

Date and Time

July 16, 2024 9:51 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Sulphur Creek #7

Structure Type

Zuni Bowl

Location

-106.596739 35.92636523

Photo 1 looking upslope

Photo 2 looking downslope


Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

Some rocks dislodged or broken

Reason for Degraded Condition

Dislodged by water

Construction Material

Igneous

Additional information on Construction Material

Rock Angularity
Angular

Zuni Bowl Rock Size
6-12"

Zuni Bowl Length
4.9

Zuni Bowl Width
4.8

Zuni Bowl Height
1.2

Lower Pour Over Height
0.4

Erosion
Undercutting

Sedimentation (for Zuni Bowl)
Partially filled

Embeddedness (for One Rock Dam)

Vegetation
76-100%

Vegetation Type
Mixture

One Rock Dam Rock Size

One Rock Dam Length

One Rock Dam Width

One Rock Dam Height

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam

Difference between ZB and ORD Condition

Additional Notes
Road immediately adjacent

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 19, 2024 3:33 PM

Date and Time

July 16, 2024 10:05 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Sulphur Creek #8

Structure Type

Zuni Bowl

Location

-106.5957161 35.9267053

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

Some rocks dislodged or broken

Reason for Degraded Condition

Dislodged by water

Construction Material

Igneous

Additional information on Construction Material

Rock Angularity
Angular

Zuni Bowl Rock Size
13-18"

Zuni Bowl Length
8.8

Zuni Bowl Width
6

Zuni Bowl Height
2

Lower Pour Over Height
0.9

Erosion
Undercutting

Sedimentation (for Zuni Bowl)
Partially filled

Embeddedness (for One Rock Dam)

Vegetation
51-75%

Vegetation Type
Mixture

One Rock Dam Rock Size

One Rock Dam Length

One Rock Dam Width

One Rock Dam Height

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam

2017

Difference between ZB and ORD Condition

Additional Notes

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 19, 2024 3:33 PM

Date and Time

July 16, 2024 10:10 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Sulphur Creek #9

Structure Type

One Rock Dam

Location

-106.5956386 35.92677082

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Igneous

Additional information on Construction Material

Rock Angularity
Partially angular

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion

Sedimentation (for Zuni Bowl)

Embeddedness (for One Rock Dam)
Partially buried

Vegetation

Vegetation Type

One Rock Dam Rock Size
13-18"

One Rock Dam Length
4.3

One Rock Dam Width
11.4

One Rock Dam Height
1.2

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2017

Difference between ZB and ORD Condition

Additional Notes

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 19, 2024 3:34 PM

Date and Time

July 16, 2024 10:17 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Sulphur Creek #10

Structure Type

Zuni Bowl

Location

-106.5953365 35.92701612

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Igneous

Additional information on Construction Material

Rock Angularity
Partially angular

Zuni Bowl Rock Size
25-36"

Zuni Bowl Length
9.5

Zuni Bowl Width
13.5

Zuni Bowl Height
4.3

Lower Pour Over Height
2.2

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Partially filled

Embeddedness (for One Rock Dam)

Vegetation
76-100%

Vegetation Type
Mixture

One Rock Dam Rock Size

One Rock Dam Length

One Rock Dam Width

One Rock Dam Height

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2017

Difference between ZB and ORD Condition

Additional Notes
Machine built

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 19, 2024 3:34 PM

Date and Time

July 16, 2024 10:43 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Sulphur Creek #11

Structure Type

Zuni Bowl

Location

-106.595385   35.92712025

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

Some rocks dislodged or broken

Reason for Degraded Condition

Dislodged by water

Construction Material

Igneous

Additional information on Construction Material

Rock Angularity
Partially angular

Zuni Bowl Rock Size
25-36"

Zuni Bowl Length
13.3

Zuni Bowl Width
11.4

Zuni Bowl Height
2.6

Lower Pour Over Height
0.3

Erosion

Sedimentation (for Zuni Bowl)
Partially buried

Embeddedness (for One Rock Dam)

Vegetation
76-100%

Vegetation Type
Mixture

One Rock Dam Rock Size

One Rock Dam Length

One Rock Dam Width

One Rock Dam Height

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2017

Difference between ZB and ORD Condition

Additional Notes
Machine built

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 19, 2024 3:34 PM

Date and Time

July 16, 2024 10:57 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Sulphur Creek #12

Structure Type

Zuni Bowl

Location

-106.5918327 35.93062668

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Igneous

Additional information on Construction Material

Rock Angularity
Partially angular

Zuni Bowl Rock Size
19-24"

Zuni Bowl Length
12

Zuni Bowl Width
16.1

Zuni Bowl Height
3

Lower Pour Over Height
1.6

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Partially buried

Embeddedness (for One Rock Dam)

Vegetation
51-75%

Vegetation Type
Grass

One Rock Dam Rock Size

One Rock Dam Length

One Rock Dam Width

One Rock Dam Height

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2017

Difference between ZB and ORD Condition

Additional Notes
Machine built

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 19, 2024 3:35 PM

Date and Time

July 16, 2024 11:38 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Sulphur Creek #13

Structure Type

Zuni Bowl and One Rock Dam

Location

-106.5919297 35.93428847

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

Some rocks dislodged or broken

Reason for Degraded Condition

Dislodged by water

Construction Material

Igneous

Additional information on Construction Material

Rock Angularity
Partially angular

Zuni Bowl Rock Size
13-18"

Zuni Bowl Length
7.1

Zuni Bowl Width
9.3

Zuni Bowl Height
2

Lower Pour Over Height
0.9

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Partially filled

Embeddedness (for One Rock Dam)
Fully buried

Vegetation
26-50%

Vegetation Type
Mixture

One Rock Dam Rock Size
6-12"

One Rock Dam Length
5.3

One Rock Dam Width
6.3

One Rock Dam Height
1.3

Distance between Zuni Bowl and One Rock Dam
14.2

Age of Zuni Bowl/One Rock Dam

2017

Difference between ZB and ORD Condition

Additional Notes

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 19, 2024 3:35 PM

Date and Time

July 16, 2024 11:47 AM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Sulphur Creek #14

Structure Type

Zuni Bowl and One Rock Dam

Location

-106.5914269 35.93480662

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition
All rocks intact

Reason for Degraded Condition

Construction Material
Igneous

Additional information on Construction Material

Rock Angularity
Partially angular

Zuni Bowl Rock Size
25-36"

Zuni Bowl Length
12

Zuni Bowl Width
20.6

Zuni Bowl Height
3

Lower Pour Over Height
0.1

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Partially filled

Embeddedness (for One Rock Dam)

Vegetation
76-100%

Vegetation Type
Grass

One Rock Dam Rock Size
13-18"

One Rock Dam Length
5.3

One Rock Dam Width
14.5

One Rock Dam Height
0.5

Distance between Zuni Bowl and One Rock Dam
7

Age of Zuni Bowl/One Rock Dam
2017

Difference between ZB and ORD Condition

Additional Notes
Machine Built

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 19, 2024 3:35 PM

Date and Time

July 16, 2024 12:06 PM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Sulphur Creek #15

Structure Type

Zuni Bowl and One Rock Dam

Location

-106.588288 35.93802508

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Igneous

Additional information on Construction Material

Rock Angularity
Partially angular

Zuni Bowl Rock Size
13-18"

Zuni Bowl Length
10.3

Zuni Bowl Width
10.7

Zuni Bowl Height
1.4

Lower Pour Over Height
0.9

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Partially filled

Embeddedness (for One Rock Dam)
Partially buried

Vegetation
76-100%

Vegetation Type
Mixture

One Rock Dam Rock Size
19-24"

One Rock Dam Length
3

One Rock Dam Width
8

One Rock Dam Height
0.8

Distance between Zuni Bowl and One Rock Dam
4.6

Age of Zuni Bowl/One Rock Dam

2017

Difference between ZB and ORD Condition

Additional Notes

NM DOT Zuni Bowl Survey
Submitted By: Anonymous user
Submitted Time: July 19, 2024 3:36 PM

Date and Time
July 16, 2024 12:15 PM

Surveyor Name
Abe Aufdermauer

Structure Identifier
Sulphur Creek #16

Structure Type
Zuni Bowl

Location
-106.5883033 35.93793888

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Igneous

Additional information on Construction Material

Rock Angularity
Partially angular

Zuni Bowl Rock Size
6-12"

Zuni Bowl Length
16.6

Zuni Bowl Width
16.2

Zuni Bowl Height
2.2

Lower Pour Over Height
0

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Partially filled

Embeddedness (for One Rock Dam)

Vegetation
76-100%

Vegetation Type
Grass

One Rock Dam Rock Size

One Rock Dam Length

One Rock Dam Width

One Rock Dam Height

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2017

Difference between ZB and ORD Condition

Additional Notes

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 19, 2024 3:36 PM

Date and Time

July 16, 2024 12:31 PM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Sulphur Creek #17

Structure Type

Zuni Bowl and One Rock Dam

Location

-106.5808215 35.9372305

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Igneous

Additional information on Construction Material

Rock Angularity
Partially angular

Zuni Bowl Rock Size
13-18"

Zuni Bowl Length
10.9

Zuni Bowl Width
11.8

Zuni Bowl Height
1.5

Lower Pour Over Height
0.7

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
No additional sediment apparent

Embeddedness (for One Rock Dam)
Partially buried

Vegetation
1-25%

Vegetation Type
Mixture

One Rock Dam Rock Size
6-12"

One Rock Dam Length
5

One Rock Dam Width
8.5

One Rock Dam Height
1

Distance between Zuni Bowl and One Rock Dam
2.6

Age of Zuni Bowl/One Rock Dam
2017

Difference between ZB and ORD Condition
Middle half of ORD dislodged

Additional Notes
Armors outlet of 50 acre pond

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 19, 2024 3:36 PM

Date and Time

July 16, 2024 12:43 PM

Surveyor Name

Abe Aufdermauer

Structure Identifier

Sulphur Creek #18

Structure Type

One Rock Dam

Location

-106.5807458 35.93718655

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Igneous

Additional information on Construction Material

Rock Angularity
Partially angular

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion
No new erosion

Sedimentation (for Zuni Bowl)

Embeddedness (for One Rock Dam)
Partially buried

Vegetation
51-75%

Vegetation Type
Mixture

One Rock Dam Rock Size
6-12"

One Rock Dam Length
4.7

One Rock Dam Width
20.9

One Rock Dam Height
0.8

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2017

Difference between ZB and ORD Condition

Additional Notes

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 19, 2024 3:36 PM

Date and Time

July 17, 2024 9:03 AM

Surveyor Name

Cameron Weber

Structure Identifier

Rodondo 1

Structure Type

One Rock Dam

Location

-106.6111231 35.85977217

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

Some rocks dislodged or broken

Reason for Degraded Condition

Dislodged by water

Construction Material

Igneous

Additional information on Construction Material

Rock Angularity
Partially angular

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion
No new erosion

Sedimentation (for Zuni Bowl)

Embeddedness (for One Rock Dam)
Partially buried

Vegetation
Bare

Vegetation Type

One Rock Dam Rock Size
6-12"

One Rock Dam Length
3.3

One Rock Dam Width
3.1

One Rock Dam Height
0.5

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2020

Difference between ZB and ORD Condition

Additional Notes

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 19, 2024 3:37 PM

Date and Time

July 17, 2024 9:10 AM

Surveyor Name

Cameron Weber

Structure Identifier

Redondo 2

Structure Type

One Rock Dam

Location

-106.6112377 35.85987838

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

Some rocks dislodged or broken

Reason for Degraded Condition

Dislodged by water

Construction Material

Igneous

Additional information on Construction Material

Rock Angularity
Partially angular

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion
Erosion around sides

Sedimentation (for Zuni Bowl)

Embeddedness (for One Rock Dam)
Partially buried

Vegetation
1-25%

Vegetation Type
Mixture

One Rock Dam Rock Size
6-12"

One Rock Dam Length
2.8

One Rock Dam Width
3.8

One Rock Dam Height
0.7

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2020

Difference between ZB and ORD Condition

Additional Notes

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 19, 2024 3:37 PM

Date and Time

July 17, 2024 9:15 AM

Surveyor Name

Cameron Weber

Structure Identifier

Redondo 3

Structure Type

One Rock Dam

Location

-106.6112516 35.8599432

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

Some rocks dislodged or broken

Reason for Degraded Condition

Dislodged by water

Construction Material
Igneous

Additional information on Construction Material

Rock Angularity
Partially angular

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion
Erosion around sides

Sedimentation (for Zuni Bowl)

Embeddedness (for One Rock Dam)
Partially buried

Vegetation
1-25%

Vegetation Type
Grass

One Rock Dam Rock Size
6-12"

One Rock Dam Length
2.2

One Rock Dam Width
3.3

One Rock Dam Height
0.7

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2020

Difference between ZB and ORD Condition

Additional Notes
Structure built too close to meander bend so more force was on one side of the structure causing erosion and dislodged rocks on river right of structure

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 19, 2024 3:37 PM

Date and Time

July 17, 2024 11:03 AM

Surveyor Name

Cameron Weber

Structure Identifier

Santa Rosa 1

Structure Type

Zuni Bowl

Location

-106.5157222 35.93745675

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

Some rocks dislodged or broken

Reason for Degraded Condition

Dislodged by water

Construction Material

Igneous

Additional information on Construction Material

Rock Angularity
Partially angular

Zuni Bowl Rock Size
13-18"

Zuni Bowl Length
9

Zuni Bowl Width
4.4

Zuni Bowl Height
1.5

Lower Pour Over Height
1.1

Erosion

Sedimentation (for Zuni Bowl)
Partially buried

Embeddedness (for One Rock Dam)

Vegetation
1-25%

Vegetation Type
Grass

One Rock Dam Rock Size

One Rock Dam Length

One Rock Dam Width

One Rock Dam Height

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2013

Difference between ZB and ORD Condition

Additional Notes
Rock rundown entry tied into upstream entry 4’ long

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 19, 2024 3:37 PM

Date and Time

July 17, 2024 11:13 AM

Surveyor Name

Cameron Weber

Structure Identifier

Santa Rosa 2

Structure Type

Zuni Bowl and One Rock Dam

Location

-106.5162171 35.93705398

Photo 1 looking upslope

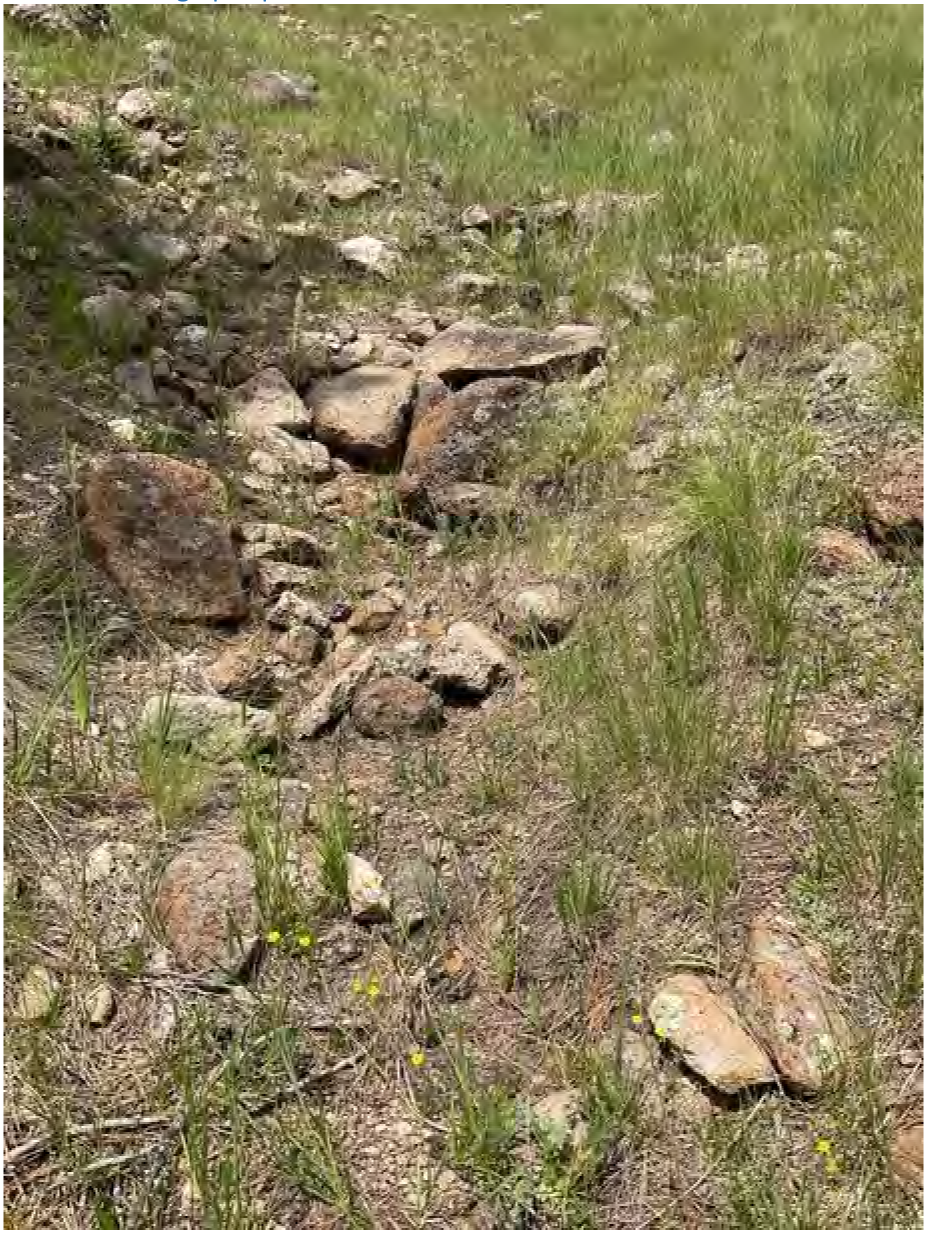

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

Some rocks dislodged or broken

Reason for Degraded Condition

Dislodged by water

Construction Material

Igneous

Additional information on Construction Material

Rock Angularity
Partially angular

Zuni Bowl Rock Size
13-18"

Zuni Bowl Length
7

Zuni Bowl Width
5.3

Zuni Bowl Height
1.6

Lower Pour Over Height
.1

Erosion

Sedimentation (for Zuni Bowl)
Partially buried

Embeddedness (for One Rock Dam)
Partially buried

Vegetation
1-25%

Vegetation Type
Mixture

One Rock Dam Rock Size
6-12"

One Rock Dam Length
4

One Rock Dam Width
4

One Rock Dam Height
.4

Distance between Zuni Bowl and One Rock Dam
3.4

Age of Zuni Bowl/One Rock Dam
2013

Difference between ZB and ORD Condition
ORD is mostly dislodged ZB is missing a few rocks

Additional Notes

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 19, 2024 3:38 PM

Date and Time

July 17, 2024 11:23 AM

Surveyor Name

Cameron Weber

Structure Identifier

Santa Rosa 3

Structure Type

Zuni Bowl

Location

-106.5159811 35.93712195

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

Some rocks dislodged or broken

Reason for Degraded Condition

Dislodged by water

Construction Material

Igneous

Additional information on Construction Material

Rock Angularity
Partially angular

Zuni Bowl Rock Size
6-12"

Zuni Bowl Length
5.7

Zuni Bowl Width
5.4

Zuni Bowl Height
1.7

Lower Pour Over Height
1.1

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Partially filled

Embeddedness (for One Rock Dam)

Vegetation
26-50%

Vegetation Type
Mixture

One Rock Dam Rock Size

One Rock Dam Length

One Rock Dam Width

One Rock Dam Height

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam

2013

Difference between ZB and ORD Condition

Additional Notes

Two tiered plunge pool built to match two tiered headcut

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 19, 2024 3:38 PM

Date and Time

July 17, 2024 12:17 PM

Surveyor Name

Cameron Weber

Structure Identifier

Santa Rosa 4

Structure Type

Zuni Bowl

Location

-106.5071629 35.93253932

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

Some rocks dislodged or broken

Reason for Degraded Condition

Dislodged by water

Construction Material

Igneous

Additional information on Construction Material

Rock Angularity
Partially angular

Zuni Bowl Rock Size
19-24"

Zuni Bowl Length
19.7

Zuni Bowl Width
14.4

Zuni Bowl Height
1.8

Lower Pour Over Height
.6

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Partially buried

Embeddedness (for One Rock Dam)

Vegetation
26-50%

Vegetation Type
Mixture

One Rock Dam Rock Size

One Rock Dam Length

One Rock Dam Width

One Rock Dam Height

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2010

Difference between ZB and ORD Condition

Additional Notes
Machine built

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user
Submitted Time: July 19, 2024 3:39 PM

Date and Time
July 17, 2024 12:24 PM

Surveyor Name
Cameron Weber

Structure Identifier
Santa Rosa 5

Structure Type
Zuni Bowl

Location
-106.5069708 35.93246877

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Igneous

Additional information on Construction Material

Rock Angularity
Mixed (some round, some angular)

Zuni Bowl Rock Size
19-24"

Zuni Bowl Length
7.6

Zuni Bowl Width
19.5

Zuni Bowl Height
1.5

Lower Pour Over Height
.2

Erosion
Undercutting

Sedimentation (for Zuni Bowl)
Partially buried

Embeddedness (for One Rock Dam)

Vegetation
1-25%

Vegetation Type
Grass

One Rock Dam Rock Size

One Rock Dam Length

One Rock Dam Width

One Rock Dam Height

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2010

Difference between ZB and ORD Condition

Additional Notes
Machine built. OED may have been built but buried.

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 19, 2024 3:39 PM

Date and Time

July 17, 2024 12:36 PM

Surveyor Name

Cameron Weber

Structure Identifier

Santa Rosa 6

Structure Type

Zuni Bowl

Location

-106.504073 35.93225377

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition
Some rocks dislodged or broken

Reason for Degraded Condition
Dislodged by water

Construction Material
Igneous

Additional information on Construction Material

Rock Angularity
Partially angular

Zuni Bowl Rock Size
25-36"

Zuni Bowl Length
21.4

Zuni Bowl Width
23.1

Zuni Bowl Height
2.7

Lower Pour Over Height
1.1

Erosion
Undercutting

Sedimentation (for Zuni Bowl)
Partially buried

Embeddedness (for One Rock Dam)

Vegetation
26-50%

Vegetation Type
Grass

One Rock Dam Rock Size

One Rock Dam Length

One Rock Dam Width

One Rock Dam Height

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2010

Difference between ZB and ORD Condition

Additional Notes
Machine built.

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 19, 2024 3:39 PM

Date and Time

July 17, 2024 12:43 PM

Surveyor Name

Cameron Weber

Structure Identifier

Santa Rosa 7

Structure Type

Zuni Bowl and One Rock Dam

Location

-106.5040297 35.93222283

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

Some rocks dislodged or broken

Reason for Degraded Condition

Dislodged by water

Construction Material

Igneous

Additional information on Construction Material

Rock Angularity
Mixed (some round, some angular)

Zuni Bowl Rock Size
25-36"

Zuni Bowl Length
23.2

Zuni Bowl Width
20.8

Zuni Bowl Height
3.4

Lower Pour Over Height
0.6

Erosion
Undercutting

Sedimentation (for Zuni Bowl)
Partially buried

Embeddedness (for One Rock Dam)
Partially buried

Vegetation
1-25%

Vegetation Type
Grass

One Rock Dam Rock Size
19-24"

One Rock Dam Length
9

One Rock Dam Width
11.5

One Rock Dam Height
0.8

Distance between Zuni Bowl and One Rock Dam
22.7

Age of Zuni Bowl/One Rock Dam

2010

Difference between ZB and ORD Condition

ZB nearly entirely intact. ORD cut around and center rocks dislodged. Steep reach.

Additional Notes

Machine built

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 19, 2024 3:39 PM

Date and Time

July 17, 2024 12:54 PM

Surveyor Name

Cameron Weber

Structure Identifier

Santa Rosa 8

Structure Type

Zuni Bowl

Location

-106.5034389 35.93217562

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

Some rocks dislodged or broken

Reason for Degraded Condition

Dislodged by water

Construction Material

Igneous

Additional information on Construction Material

Rock Angularity
Mixed (some round, some angular)

Zuni Bowl Rock Size
25-36"

Zuni Bowl Length
21

Zuni Bowl Width
20.4

Zuni Bowl Height
2.3

Lower Pour Over Height
0.9

Erosion
Undercutting

Sedimentation (for Zuni Bowl)
Partially filled

Embeddedness (for One Rock Dam)

Vegetation
51-75%

Vegetation Type
Grass

One Rock Dam Rock Size

One Rock Dam Length

One Rock Dam Width

One Rock Dam Height

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2010

Difference between ZB and ORD Condition

Additional Notes
Machine built. Near roadway.

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 19, 2024 3:40 PM

Date and Time

July 17, 2024 1:34 PM

Surveyor Name

Cameron Weber

Structure Identifier

La Jara 1

Structure Type

Zuni Bowl and One Rock Dam

Location

-106.5187872 35.8651939

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Igneous

Additional information on Construction Material

Rock Angularity
Mixed (some round, some angular)

Zuni Bowl Rock Size
13-18"

Zuni Bowl Length
7.8

Zuni Bowl Width
7

Zuni Bowl Height
1.2

Lower Pour Over Height
0.6

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
No additional sediment apparent

Embeddedness (for One Rock Dam)

Vegetation
1-25%

Vegetation Type
Mixture

One Rock Dam Rock Size
6-12"

One Rock Dam Length
3.4

One Rock Dam Width
6.5

One Rock Dam Height
0.3

Distance between Zuni Bowl and One Rock Dam
0.8

Age of Zuni Bowl/One Rock Dam
2018

Difference between ZB and ORD Condition
ORD center rocks dislodged

Additional Notes
Submerged

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: July 19, 2024 3:40 PM

Date and Time

July 17, 2024 1:43 PM

Surveyor Name

Cameron Weber

Structure Identifier

La Jara 2

Structure Type

Zuni Bowl and One Rock Dam

Location

-106.5187878 35.86520847

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Igneous

Additional information on Construction Material

Rock Angularity
Partially angular

Zuni Bowl Rock Size
13-18"

Zuni Bowl Length
6.1

Zuni Bowl Width
7

Zuni Bowl Height
0.9

Lower Pour Over Height
0.6

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Partially filled

Embeddedness (for One Rock Dam)
Partially buried

Vegetation
1-25%

Vegetation Type
Mixture

One Rock Dam Rock Size
13-18"

One Rock Dam Length
1.7

One Rock Dam Width
6.3

One Rock Dam Height
1

Distance between Zuni Bowl and One Rock Dam
0.1

Age of Zuni Bowl/One Rock Dam

2018

Difference between ZB and ORD Condition

Additional Notes

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: August 20, 2024 12:09 PM

Date and Time

August 20, 2024 7:54 AM

Surveyor Name

Karen Menetrey

Structure Identifier

SFCT GAL #1

Structure Type

Zuni Bowl and One Rock Dam

Location

-105.9419599 35.44480557

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition
All rocks intact

Reason for Degraded Condition

Construction Material
Sedimentary

Additional information on Construction Material
Sandstone

Rock Angularity
Angular

Zuni Bowl Rock Size
6-12"

Zuni Bowl Length
8.9

Zuni Bowl Width
7.5

Zuni Bowl Height
1.5

Lower Pour Over Height
.2

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Partially filled

Embeddedness (for One Rock Dam)
Partially buried

Vegetation
1-25%

Vegetation Type
Mixture

One Rock Dam Rock Size
6-12"

One Rock Dam Length
3.7

One Rock Dam Width
10.2

One Rock Dam Height
.2

Distance between Zuni Bowl and One Rock Dam
4.7

Age of Zuni Bowl/One Rock Dam
2021

Difference between ZB and ORD Condition

Additional Notes

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: August 20, 2024 12:10 PM

Date and Time

August 20, 2024 8:10 AM

Surveyor Name

Karen Menetrey

Structure Identifier

SFCT GAL #2

Structure Type

Zuni Bowl and One Rock Dam

Location

-105.9418646 35.44469897

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Sedimentary

Additional information on Construction Material
Sandstone

Rock Angularity
Angular

Zuni Bowl Rock Size
6-12"

Zuni Bowl Length
6.4

Zuni Bowl Width
4.5

Zuni Bowl Height
.9

Lower Pour Over Height
.5

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Partially filled

Embeddedness (for One Rock Dam)
Partially buried

Vegetation
1-25%

Vegetation Type
Mixture

One Rock Dam Rock Size
6-12"

One Rock Dam Length
2.7

One Rock Dam Width
5.8

One Rock Dam Height
.4

Distance between Zuni Bowl and One Rock Dam
4.3

Age of Zuni Bowl/One Rock Dam
2021

Difference between ZB and ORD Condition

Additional Notes

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: August 20, 2024 12:12 PM

Date and Time

August 20, 2024 8:26 AM

Surveyor Name

Karen Menetrey

Structure Identifier

SFCT GAL #3

Structure Type

Zuni Bowl and One Rock Dam

Location

-105.9424022 35.44424813

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Mixture of rock types

Additional information on Construction Material

Sandstone and some igneous gathered on site

Rock Angularity
Angular

Zuni Bowl Rock Size
6-12"

Zuni Bowl Length
6.9

Zuni Bowl Width
7.7

Zuni Bowl Height
1.0

Lower Pour Over Height
.9

Erosion
A little erosion between ZB and ORD due to steep slope.

Sedimentation (for Zuni Bowl)
Partially filled

Embeddedness (for One Rock Dam)
Partially buried

Vegetation
1-25%

Vegetation Type
Mixture

One Rock Dam Rock Size
6-12"

One Rock Dam Length
3.7

One Rock Dam Width
9.4

One Rock Dam Height
.4

Distance between Zuni Bowl and One Rock Dam
7.5

Age of Zuni Bowl/One Rock Dam
2023

Difference between ZB and ORD Condition

Additional Notes

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: August 20, 2024 12:14 PM

Date and Time

August 20, 2024 8:39 AM

Surveyor Name

Karen Menetrey

Structure Identifier

SFCT GAL #4

Structure Type

Zuni Bowl and One Rock Dam

Location

-105.9423819 35.44427455

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Unknown

Construction Material

Mixture of rock types

Additional information on Construction Material
Sandstone and igneous collected on site. Sandstone from a quarry between Bernal and Romeroville.

Rock Angularity
Angular

Zuni Bowl Rock Size
6-12"

Zuni Bowl Length
4.7

Zuni Bowl Width
5.1

Zuni Bowl Height
1.1

Lower Pour Over Height
.4

Erosion
Erosion between ZB and ORD due to steep slope

Sedimentation (for Zuni Bowl)
Partially filled

Embeddedness (for One Rock Dam)
Partially buried

Vegetation
1-25%

Vegetation Type
Grass

One Rock Dam Rock Size
6-12"

One Rock Dam Length
3.3

One Rock Dam Width
3.8

One Rock Dam Height
.2

Distance between Zuni Bowl and One Rock Dam
3.5

Age of Zuni Bowl/One Rock Dam
2023

Difference between ZB and ORD Condition

Additional Notes

NM DOT Zuni Bowl Survey
Submitted By: Anonymous user
Submitted Time: August 20, 2024 12:15 PM

Date and Time
August 20, 2024 8:53 AM

Surveyor Name
Karen Menetrey

Structure Identifier
SFCT GAL #5

Structure Type
Zuni Bowl and One Rock Dam

Location
-105.9424171 35.44438518

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition
Some rocks dislodged or broken

Reason for Degraded Condition
Dislodged by water

Construction Material
Sedimentary

Additional information on Construction Material
Sandstone

Rock Angularity
Angular

Zuni Bowl Rock Size
6-12"

Zuni Bowl Length
5.6

Zuni Bowl Width
5.3

Zuni Bowl Height
2.0

Lower Pour Over Height
.1

Erosion
Undercutting

Sedimentation (for Zuni Bowl)
Partially filled

Embeddedness (for One Rock Dam)
Partially buried

Vegetation
1-25%

Vegetation Type
Grass

One Rock Dam Rock Size
6-12"

One Rock Dam Length
2.5

One Rock Dam Width
4.5

One Rock Dam Height
.1

Distance between Zuni Bowl and One Rock Dam
12.6

Age of Zuni Bowl/One Rock Dam

2021

Difference between ZB and ORD Condition

Additional Notes

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: August 20, 2024 12:16 PM

Date and Time

August 20, 2024 9:04 AM

Surveyor Name

Karen Menetrey

Structure Identifier

SFCT GAL #6

Structure Type

Zuni Bowl and One Rock Dam

Location

-105.942457 35.44432338

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Sedimentary

Additional information on Construction Material

Sandstone

Rock Angularity
Angular

Zuni Bowl Rock Size
6-12"

Zuni Bowl Length
5.3

Zuni Bowl Width
4.2

Zuni Bowl Height
1.4

Lower Pour Over Height
.1

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Partially buried

Embeddedness (for One Rock Dam)
Partially buried

Vegetation
1-25%

Vegetation Type
Grass

One Rock Dam Rock Size
6-12"

One Rock Dam Length
2.3

One Rock Dam Width
4.8

One Rock Dam Height
.3

Distance between Zuni Bowl and One Rock Dam
1.0

Age of Zuni Bowl/One Rock Dam

2021

Difference between ZB and ORD Condition

Additional Notes

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: August 20, 2024 12:17 PM

Date and Time

August 20, 2024 9:18 AM

Surveyor Name

Karen Menetrey

Structure Identifier

SFCT GAL #7

Structure Type

Zuni Bowl

Location

-105.9429858 35.44385002

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Sedimentary

Additional information on Construction Material

Sansatone

Rock Angularity
Angular

Zuni Bowl Rock Size
6-12"

Zuni Bowl Length
4.5

Zuni Bowl Width
4.7

Zuni Bowl Height
1.0

Lower Pour Over Height
.3

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Partially filled

Embeddedness (for One Rock Dam)

Vegetation
1-25%

Vegetation Type
Grass

One Rock Dam Rock Size

One Rock Dam Length

One Rock Dam Width

One Rock Dam Height

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam

2022

Difference between ZB and ORD Condition

Additional Notes

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: August 20, 2024 12:19 PM

Date and Time

August 20, 2024 9:26 AM

Surveyor Name

Karen Menetrey

Structure Identifier

SFCT GAL #8

Structure Type

Zuni Bowl and One Rock Dam

Location

-105.9428874 35.44374573

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition
All rocks intact

Reason for Degraded Condition

Construction Material
Sedimentary

Additional information on Construction Material
Sandstone

Rock Angularity
Angular

Zuni Bowl Rock Size
6-12"

Zuni Bowl Length
7.0

Zuni Bowl Width
5.8

Zuni Bowl Height
.9

Lower Pour Over Height
.1

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Partially buried

Embeddedness (for One Rock Dam)
Partially buried

Vegetation
1-25%

Vegetation Type
Grass

One Rock Dam Rock Size
6-12"

One Rock Dam Length
2.0

One Rock Dam Width
6.3

One Rock Dam Height
.2

Distance between Zuni Bowl and One Rock Dam
2.5

Age of Zuni Bowl/One Rock Dam
2022

Difference between ZB and ORD Condition

Additional Notes

NM DOT Zuni Bowl Survey

Submitted By: susan.lime_NMDOT

Submitted Time: October 3, 2024 8:32 AM

Date and Time

September 1, 2024 12:46 PM

Surveyor Name

Cameron Weber

Structure Identifier

Susan Lime #3

Structure Type

Zuni Bowl

Location

-106.2243189 35.85993323

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition
Some rocks dislodged or broken

Reason for Degraded Condition
Dislodged by water

Construction Material
Mixture of rock types

Additional information on Construction Material
Working based on precious visit, this strucure has collected 6 inches of fine sediment

Rock Angularity

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion

Sedimentation (for Zuni Bowl)

Embeddedness (for One Rock Dam)

Vegetation

Vegetation Type

One Rock Dam Rock Size

One Rock Dam Length

One Rock Dam Width

One Rock Dam Height

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam

Difference between ZB and ORD Condition

Additional Notes

NM DOT Zuni Bowl Survey

Submitted By: susan.lime_NMDOT

Submitted Time: October 3, 2024 8:33 AM

Date and Time

September 1, 2024 12:50 PM

Surveyor Name

Cameron Weber

Structure Identifier

Susan Lime #2

Structure Type

Zuni Bowl and One Rock Dam

Location

-106.2243784 35.85996151

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

Some rocks dislodged or broken

Reason for Degraded Condition

Dislodged by water

Construction Material

Mixture of rock types

Additional information on Construction Material

Natural chanmel down stream of one rock dam

Rock Angularity

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion

Sedimentation (for Zuni Bowl)

Embeddedness (for One Rock Dam)

Vegetation

Vegetation Type

One Rock Dam Rock Size

One Rock Dam Length

One Rock Dam Width

One Rock Dam Height

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam

Difference between ZB and ORD Condition

Additional Notes

NM DOT Zuni Bowl Survey

Submitted By: susan.lime_NMDOT

Submitted Time: October 3, 2024 8:33 AM

Date and Time

September 1, 2024 12:55 PM

Surveyor Name

Cameron Weber

Structure Identifier

Susan Lime #1

Structure Type

One Rock Dam

Location

-106.2244515 35.86014432

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Mixture of rock types

Additional information on Construction Material

Scour channel downstream. Mulch sock stabilization of bank to the left (facing downstream).

Rock Angularity

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion

Sedimentation (for Zuni Bowl)

Embeddedness (for One Rock Dam)

Vegetation

Vegetation Type

One Rock Dam Rock Size

One Rock Dam Length

One Rock Dam Width

One Rock Dam Height

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam

Difference between ZB and ORD Condition

Additional Notes

NM DOT Zuni Bowl Survey
Submitted By: Anonymous user
Submitted Time: October 23, 2024 5:42 PM

Date and Time
October 23, 2024 11:44 AM

Surveyor Name
Cameron Weber

Structure Identifier
Embudo #1

Structure Type
One Rock Dam

Location
-105.9078511 36.18872842

Photo 1 looking upslope


Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition
All rocks intact

Reason for Degraded Condition

Construction Material
Metamorphic

Additional information on Construction Material

Rock Angularity
Round

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion

Sedimentation (for Zuni Bowl)

Embeddedness (for One Rock Dam)

Gaps between rocks

Vegetation

1-25%

Vegetation Type

Forbs

One Rock Dam Rock Size

6-12"

One Rock Dam Length

3.4

One Rock Dam Width

16.1

One Rock Dam Height

0.3

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam

2023

Difference between ZB and ORD Condition

Additional Notes

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: October 23, 2024 5:42 PM

Date and Time

October 23, 2024 1:02 PM

Surveyor Name

Cameron Weber

Structure Identifier

Embudo #2

Structure Type

One Rock Dam

Location

-105.9088917 36.18696822

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition

All rocks intact

Reason for Degraded Condition

Construction Material

Igneous

Additional information on Construction Material

Rock Angularity

Partially angular

Zuni Bowl Rock Size

Zuni Bowl Length

Zuni Bowl Width

Zuni Bowl Height

Lower Pour Over Height

Erosion
No new erosion

Sedimentation (for Zuni Bowl)

Embeddedness (for One Rock Dam)
Gaps between rocks

Vegetation
26-50%

Vegetation Type
Grass

One Rock Dam Rock Size
6-12"

One Rock Dam Length
2.7

One Rock Dam Width
3.9

One Rock Dam Height
0.3

Distance between Zuni Bowl and One Rock Dam

Age of Zuni Bowl/One Rock Dam
2023

Difference between ZB and ORD Condition

Additional Notes

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: November 4, 2024 4:51 PM

Date and Time

October 30, 2024 1:28 PM

Surveyor Name

Cameron Weber

Structure Identifier

Embudo #3

Structure Type

Zuni Bowl and One Rock Dam

Location

-105.9015625 36.18700093

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition
All rocks intact

Reason for Degraded Condition

Construction Material
Igneous

Additional information on Construction Material
Granite, cobble

Rock Angularity
Round

Zuni Bowl Rock Size
6-12"

Zuni Bowl Length
6.5

Zuni Bowl Width
4.5

Zuni Bowl Height
1.2

Lower Pour Over Height
1.5

Erosion
Undercutting

Sedimentation (for Zuni Bowl)
No additional sediment apparent

Embeddedness (for One Rock Dam)
Partially buried

Vegetation
Bare

Vegetation Type

One Rock Dam Rock Size
6-12"

One Rock Dam Length
3.25

One Rock Dam Width
6.0

One Rock Dam Height
.4

Distance between Zuni Bowl and One Rock Dam
7

Age of Zuni Bowl/One Rock Dam
2023

Difference between ZB and ORD Condition

Additional Notes
Willow regeneration on banks. 75% sedimentation in channel up to structure height.

NM DOT Zuni Bowl Survey
Submitted By: Anonymous user
Submitted Time: November 4, 2024 4:51 PM

Date and Time
October 30, 2024 2:16 PM

Surveyor Name
Cameron Weber

Structure Identifier
Embudo #4

Structure Type
Zuni Bowl and One Rock Dam

Location
-105.892229 36.18216896

Photo 1 looking upslope


Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition
All rocks intact

Reason for Degraded Condition

Construction Material
Sedimentary

Additional information on Construction Material
Limestone

Rock Angularity
Round

Zuni Bowl Rock Size
6-12"

Zuni Bowl Length
6.25

Zuni Bowl Width
4.8

Zuni Bowl Height
2.2

Lower Pour Over Height
.8

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Partially buried

Embeddedness (for One Rock Dam)
Partially buried

Vegetation
51-75%

Vegetation Type
Mixture

One Rock Dam Rock Size
6-12"

One Rock Dam Length
3.4

One Rock Dam Width
4.4

One Rock Dam Height
.8

Distance between Zuni Bowl and One Rock Dam
7.75

Age of Zuni Bowl/One Rock Dam
2023

Difference between ZB and ORD Condition

Additional Notes
There is a rock run down on RL that feeds into ZB. Grass, Forbes, horsetail in ZB.

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: November 4, 2024 4:51 PM

Date and Time

October 30, 2024 10:12 PM

Surveyor Name

Cameron Weber

Structure Identifier

Embudo #5

Structure Type

Zuni Bowl and One Rock Dam

Location

-105.90233 36.184721

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition
All rocks intact

Reason for Degraded Condition

Construction Material
Metamorphic

Additional information on Construction Material
Granite

Rock Angularity
Round

Zuni Bowl Rock Size
6-12"

Zuni Bowl Length
6.25

Zuni Bowl Width
5

Zuni Bowl Height
2.5

Lower Pour Over Height
.8

Erosion
No new erosion

Sedimentation (for Zuni Bowl)
Partially filled

Embeddedness (for One Rock Dam)
Partially buried

Vegetation
26-50%

Vegetation Type
Forbs

One Rock Dam Rock Size
6-12"

One Rock Dam Length
2.6

One Rock Dam Width
2.9

One Rock Dam Height
.6

Distance between Zuni Bowl and One Rock Dam
9

Age of Zuni Bowl/One Rock Dam
2023

Difference between ZB and ORD Condition
ORD very sedimented

Additional Notes
Horsetail filling in the structures

NM DOT Zuni Bowl Survey

Submitted By: Anonymous user

Submitted Time: November 4, 2024 4:51 PM

Date and Time

October 30, 2024 2:02 PM

Surveyor Name

Cameron Weber

Structure Identifier

Embudo #6

Structure Type

Zuni Bowl and One Rock Dam

Location

-105.901541 36.18692301

Photo 1 looking upslope

Photo 2 looking downslope

Photo 3 looking cross slope (valley right)

Photo 4 looking cross slope (valley left)

Condition
All rocks intact

Reason for Degraded Condition

Construction Material
Igneous

Additional information on Construction Material
Granite

Rock Angularity
Round

Zuni Bowl Rock Size
6-12"

Zuni Bowl Length
6.6

Zuni Bowl Width
4

Zuni Bowl Height
1.6

Lower Pour Over Height
1

Erosion
Erosion around sides

Sedimentation (for Zuni Bowl)
Partially filled

Embeddedness (for One Rock Dam)
Partially buried

Vegetation
1-25%

Vegetation Type
Forbs

One Rock Dam Rock Size
6-12"

One Rock Dam Length
2.4

One Rock Dam Width
3.9

One Rock Dam Height
.4

Distance between Zuni Bowl and One Rock Dam
4.6

Age of Zuni Bowl/One Rock Dam
2023

Difference between ZB and ORD Condition

Additional Notes
Some piping at bottom right of ZB below pour over key in.

Appendix D. Workshop Attendance Sheet

ZUNI BOWL AND ONE ROCK DAM WORKSHOP SIGN IN

PROJECT:	R924060	**MEETING DATE:**	11/6/2024
FACILITATOR:	RGR and NMDOT	**LOCATION:**	GO Training Room

NAME	TITLE	EMAIL
Abigail Moya	Project Mgr	abigail.moya@dot.nm.gov
RANDY TRUJILLO	RESEARCH OPS	RANDOLPH.TRUJILLO@DOT.NM.GOV
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Antonio Griego	MS4 Coordinator	antonio.griego@dot.nm.gov
Karen Menetrey	Dir. Ecological Opportunities	
Abe Aufdermaur	RGR FIELD SERVICES	abe@riograndereturn.org
Cameron Weber	Conservation Pgm Director	cameron@riograndereturn.org
Shannon Vigil	Program Coordinator	shannon.vigil@dot.nm.gov
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Steven Gisler	NMDOT Environmental	steven.gisler@dot.nm.gov
Kayla Fuentes	EIT	kayla.fuentes@dot.nm.gov
ERICA G. NEWMAN	DRAINAGE DESIGN BUREAU	erica.newman@dot.nm.gov
16. Emily Dossett	CR Sup/TIVA Coord.	emily.dossett@dot.nm.gov
17. Rudolph Archuleta	NMDOT	

Appendix E. Workshop Agenda and Presentations

Zuni Bowl/One Rock Dam Workshop Agenda

by Rio Grande Return

for NM Department of Transportation Research Bureau

November 6, 2024

Classroom: 8:30am – 12:00pm

Field Trip: 1:00pm - 3:00pm

Instructors: Cameron Weber, Karen Menetrey, and Abe Aufdermauer

8:30 – 8:45am	Introductions (Karen)
8:45 – 9:00am	Anatomy of a Headcut (Karen)
9:00 – 9:30am	Schematic Diagrams for Zuni Bowls and One Rock Dams (Karen)
9:30 – 10:00am	How to Lay Out a Structure (Cameron)
10:00 – 10:15am	Break
10:15 – 10:30am	Materials: Evaluation of Onsite Rocks/ Ordering Rocks from a Supplier (Cameron)
10:30 – 10:45am	Safety: Moving Rocks and Handling Tools (Cameron)
10:45 – 12:00pm	Desktop Zuni Bowl/One Rock Dam Building Exercise (Karen, Cameron, Abe)
12:00 – 12:45pm	Lunch
12:45 – 1:00pm	Load up in vehicles and drive to Santa Fe Botanical Gardens
1:00 - 3:00pm	Walk arroyo at Santa Fe Botanical Garden and view erosion control structures (weather-permitting)

RIO GRANDE RETURN

Erosion Control using Zuni Bowls & One Rock Dams

RIO GRANDE RETURN

NMDOT Workshop

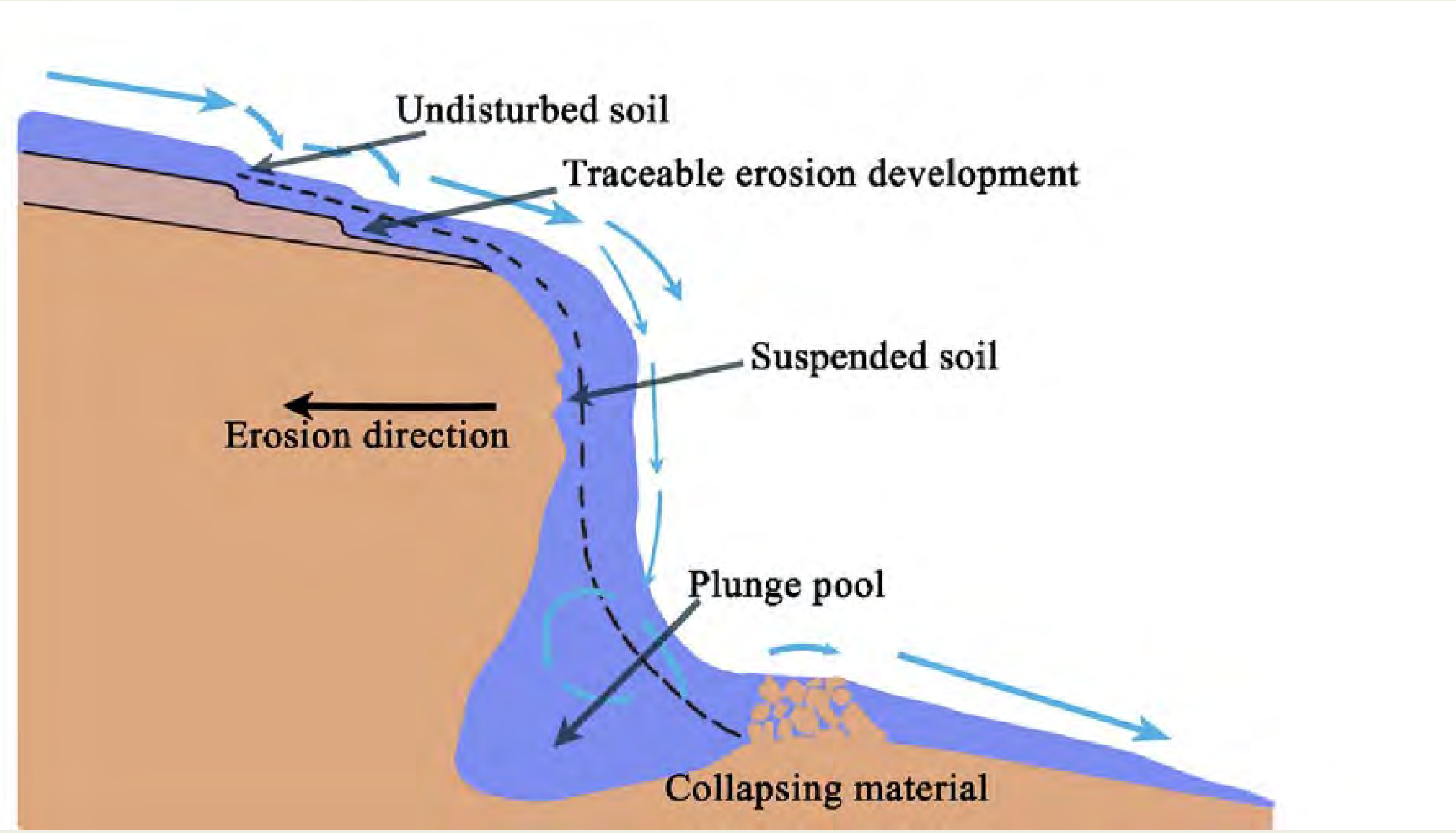
November 2024

Headcuts are characterized by:

- A waterfall or abrupt change of slope in a streambed or flow path.
- A fragile, cracked, or crumbling lip of the waterfall (headcut pour-over).
- A bowl-shaped pool at the base of the falls (plunge pool).
- Undercutting. Water turbulence undercuts the headwall.
- Rapid, headward erosion during flood flow.
- Drying, cracking and sloughing during the dry season through exposure to sun and air.
- The higher the waterfall, the more erosive power water has.

Diagrams of a Headcut

Picture 1: A dangerous head-cut next to a road

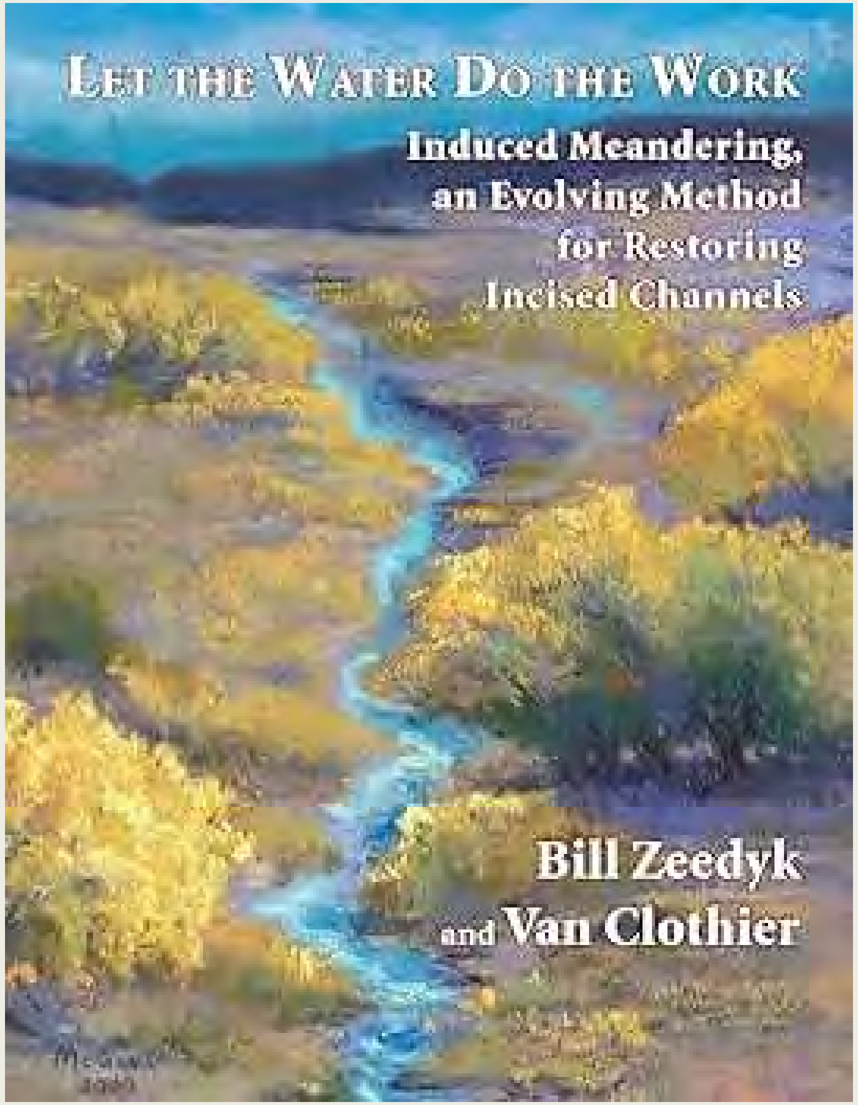


Healing principles for headcuts:

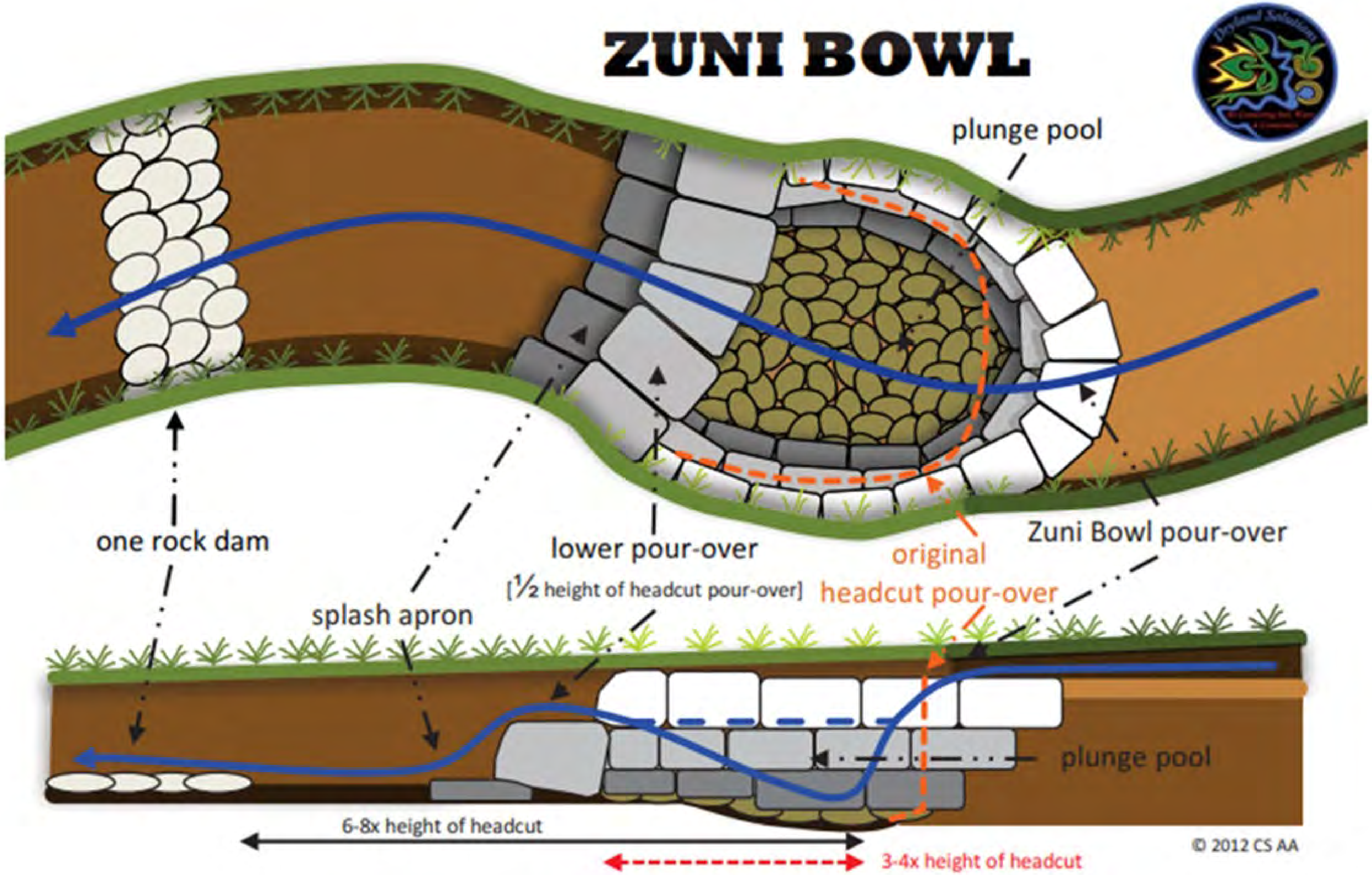
- Lower the height of the waterfall in order to reduce the force of the falling water (by making many short steps instead of a long fall).
- Widen the lip of the pour-over to disperse concentrated flow.
- Harden the base of the waterfall to protect the substrate from erosion.
- Conserve soil moisture to enhance plant growth and root densities.

Let the Water Do the Work

- Zuni Bowls are examples of Traditional Ecological Knowledge – also present on other SW tribal lands (e.g. Navajo and Hopi).
- Bill retired from the US Forest Service and continued working on watershed restoration.
- Zuni Bowls and One Rock Dams are among several “Zeedyk Structures” (Nature-Based Solutions, Natural Infrastructure in Dryland Streams, Low Tech Process-Based Restoration) Adopted by US Department of Agriculture.
- Zeedyk structures have been built in many states and countries.



ZUNI BOWL


plunge pool
one rock dam
lower pour-over
[½ height of headcut pour-over]
original
headcut pour-over
Zuni Bowl pour-over
splash apron
plunge pool
6-8x height of headcut
3-4x height of headcut
© 2012 CS AA

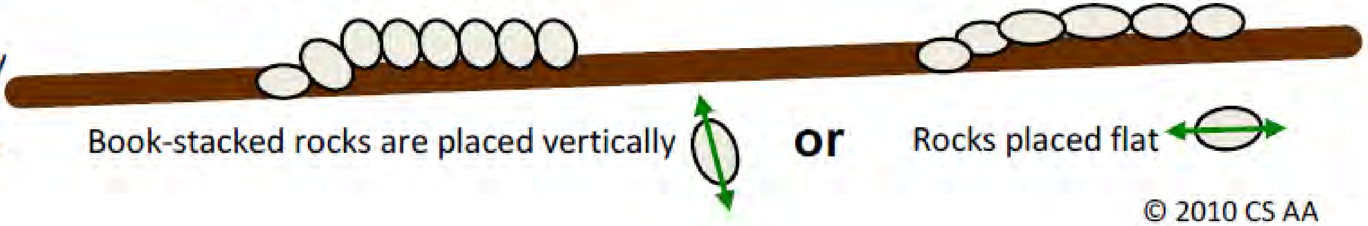
ONE ROCK DAM "ORD"

*A low grade control structure built with a single layer of rock on the bed of the channel. ORDs stabilize the bed of the channel by slowing the flow of water, increasing roughness, recruiting vegetation, capturing sediment, and **gradually** raising the bed level over time. ORDs are also passive water harvesting structures. The single layer of rock is an effective rock mulch that increases soil moisture, infiltration, and plant growth. Original concept developed by Bill Zeedyk.*

Design & Construction

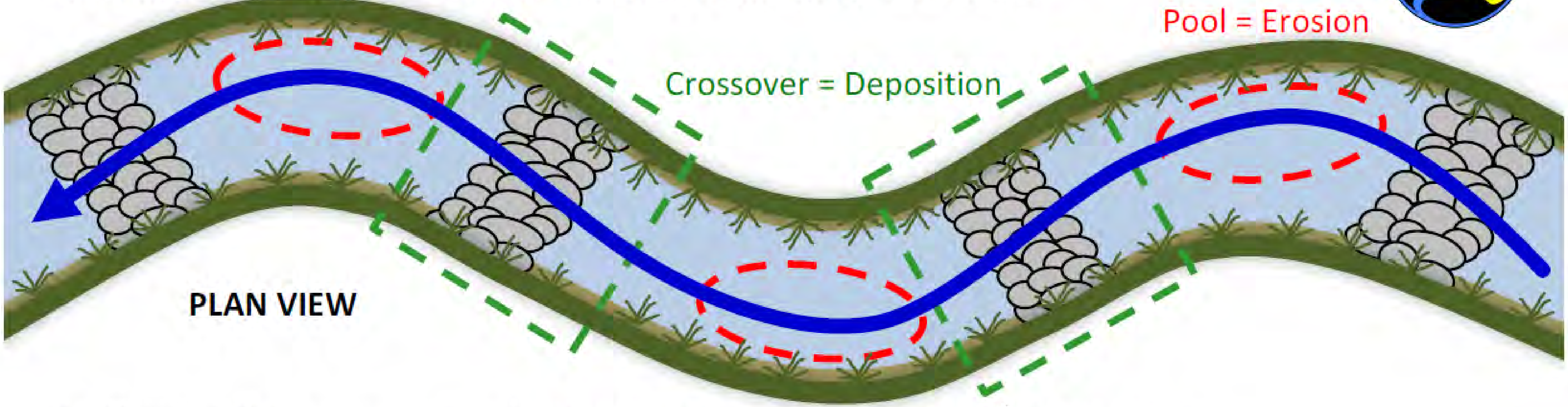
1. Select area to build the ORD. Dig a shallow footer trench and fill with one or two rows of rock, so that no rock protrudes more than 2 in/5cm above the bed of the channel. This will serve as the ***splash apron*** for the ORD.
2. Scatter native grass and wildflower seeds in the area where the ORD is to be built.
3. Start building at the footer and continue upstream, laying down one layer of rock, as if you were building a horizontal wall on the bed of the channel.
4. Over time, the ORD will fill with sediment. Once completely filled, another offset layer can be added to the ORD to further raise the bed of the channel and capture more sediment. The original ORD becomes the splash apron for the new layer.

Orientation of Rocks: Placing rocks vertically is called book-stacking. This makes for a very strong structure, especially when using small rocks. It is also a good way to make a slightly taller structure.

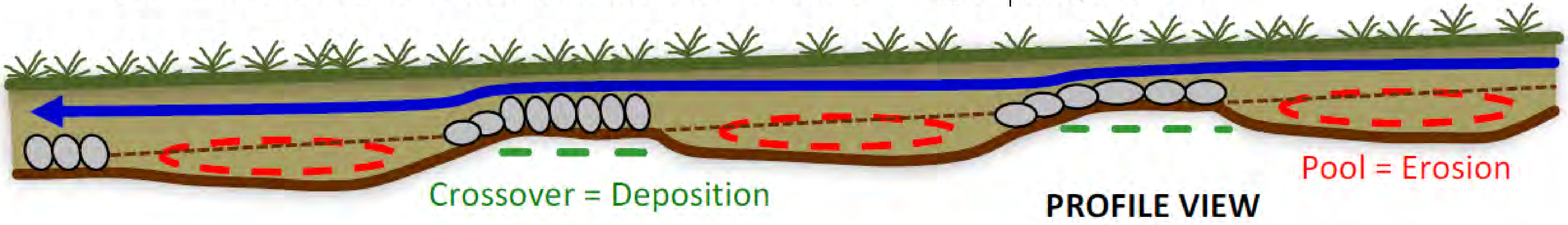


ONE ROCK DAM

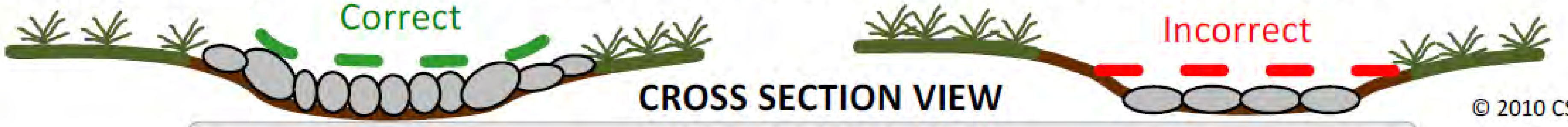
1. Always position grade control structures at meander crossovers.



2. Placement at crossovers maintains natural erosion and deposition patterns.



3. Always maintain a low point in the channel cross section to prevent bank erosion.




Galisteo Basin
Santa Fe Community Trust
Photo by Jan-Willem Jansens

Rio Mora NWR
Photo by Phil Carter


Sulphur Creek
Photo by Karen Menetrey


Sulphur Creek
Photo by Karen Menetrey

Santa Rosa Creek
Photo Karen Menetrey

Grassy Creek, Valle Vidal
Photo by Karen Menetrey


Dixon
Photo by Jan-Willem Jansens

Rio Mora NWR
Photo by Kristina Fisher

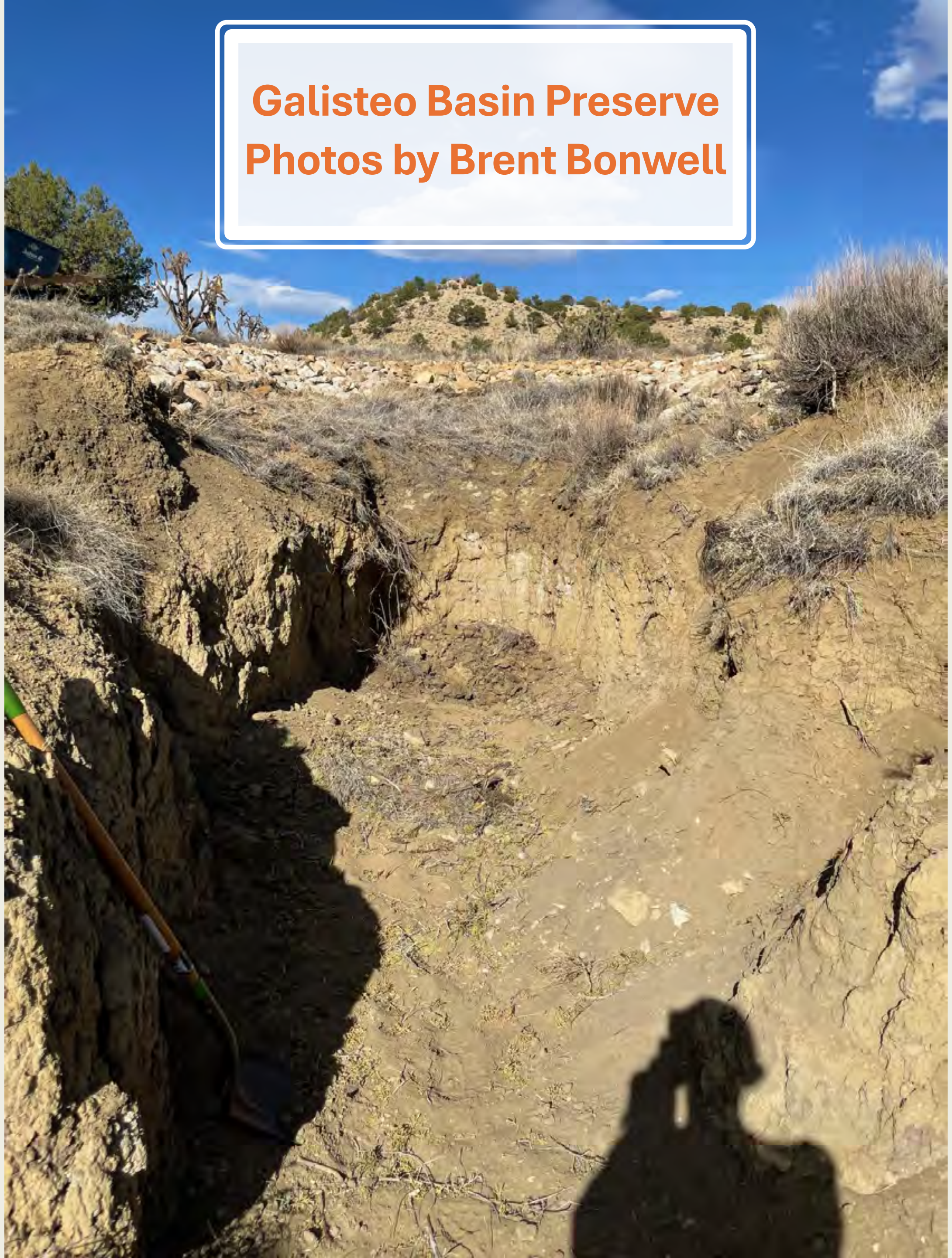

Galisteo Basin
Santa Fe Community Trust
Photo by Jan-Willem Jansens

Dixon
Photo by Jan-Willem Jansens

Rio Mora NWR
Photos by Kristina Fisher


Rio Mora NWR
Photo by Kristina Fisher

Galisteo Basin Preserve
Photo by Brent Bonwell


Galisteo Basin Preserve
Photos by Brent Bonwell

Galisteo Basin Preserve
Photo by Brent Bonwell

Santa Fe River
Photo by Karen Menetrey

Sulphur Creek
Photo by Karen Menetrey

Rio Mora NWR
Photos by Kristina Fisher

Ft. Union National Monument
Photo by Kristina Fisher

Sulphur Creek
Photo by Karen Menetrey

How to Lay Out a Rock Structure and Safely Build It

NM DOT Workshop

November 2024

RIO GRANDE RETURN

ROCK STRUCTURES

WHY BUILD STRUCTURES WITH ROCKS?

The following structures are constructed by gathering and arranging rocks of various shapes and sizes into interlocking patterns. There are many benefits to using rocks to build restoration structures, one being they are plentiful in many remote settings. Another is rocks are naturally occurring on the landscape unlike concrete or other man made materials and provide a long-term element that doesn't need to be removed later. Using local rocks reduces restoration costs and fossil fuels to transport materials. Some rocks are quite massive which can provide structural stability and strength.

Since there are many different shapes and sizes of rocks, they each perform a unique function. Larger rocks act as support or anchors whereas smaller rocks may be used to fill gaps between the larger ones (known as **chinking**). Rocks that have a relatively flat surface are perfect for the foundation of certain structures.

Safety Note: The most common injury when working with rocks is hitting or crushing your body parts. Always be aware of your body position and surroundings when moving rocks. Some rocks may be housing wildlife beneath them (ex. snakes, lizards, spiders) so try not to disturb them or put yourself in harms way. When rolling large rocks downhill, always call out "Rock" so crew members are aware.

ZUNI BOWL

Zuni Bowl constructed by HPWA seasonal crews in Sapello (Fall 2023).

DESCRIPTION & RESTORATION PURPOSE

The Zuni Bowl is an in-channel head-cut control structure that was first observed and developed by Bill Zeedyk and the people of the Zuni Pueblo in New Mexico. The Zuni Bowl uses the principles of step-pools and natural cascades to dissipate the energy of water falling from the pour-over of a head-cut. This stabilizes the head-cuts by creating two or more subtle falls to replace the fall from the original head-cut that is usually actively eroding. If successful, the structure will also allow better retention of moisture in the bowl and below the head-cut, promoting vegetation growth.

APPROPRIATE LOCATIONS

Head-cuts under 3ft in height can be addressed by a hand-built Zuni Bowl. Zuni Bowls in head-cuts greater than 3 ft in height may require assistance from heavy equipment and large rocks. Some treatment areas may already have a bowl-like shape or large boulders to incorporate into the structure.

CONSTRUCTION PROCESS

<u>Step 1:</u> Start by selecting an appropriate head-cut to address. Shape and lay back the face of the head-cut to create a uniform surface on which to build. Level the base of the head-cut and below where the basin will be built by removing loose material (rocks, roots, etc.) and other irregularities.


ZUNI BOWL

CONSTRUCTION PROCESS (CONTINUED)

Step 2: Gather and stage rocks of varying shapes and sizes, selecting many large, angular and flat rocks.

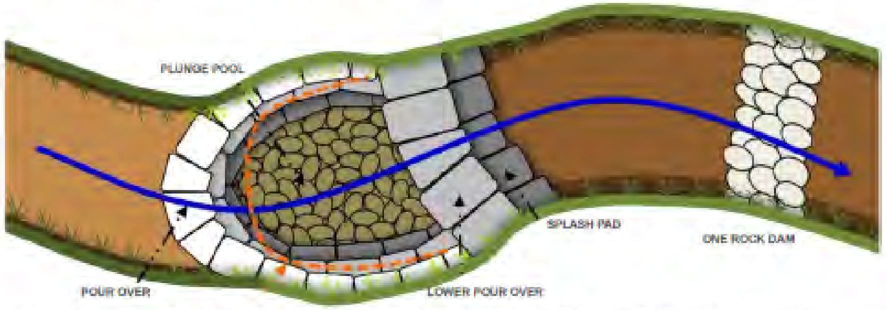
Step 3: Line the base (downstream end) of the Zuni Bowl with large, flatter rocks to create a splash pad for the structure.

Step 4: Arrange the next row of rocks overlapping ⅔ the splash pad. These rocks should sit at an elevation approximately 1/2 the total height of the headcut if possible.This will form the lower pour over of the bowl.

Step 5: Line the bottom of the basin of the structure with rocks to create the plunge pool. Continue stacking rocks up to the height of the headcut. Be careful not to build above this height. This forms the walls of the bowl.

Step 6: Continue arranging rocks until the desired rock basin shape is achieved, filling any gaps water could potentially move through.

Step 7: Construct an *ORD* downstream from the Zuni Bowl. Place the upstream edge of the ORD approximately six to eight times (6-8x) the height of the headcut away from the Zuni Bowl pour-over.

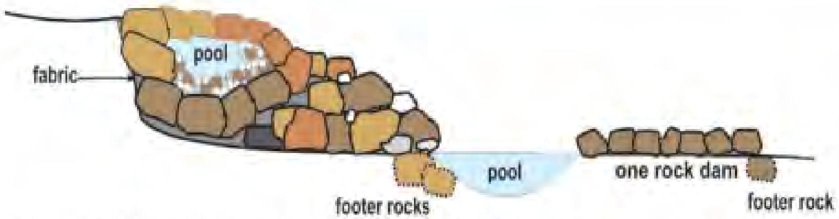


Schematic of Zuni Bowl from Erosion Control Field Guide, Quivira Coalition & Watershed Artisans



#17

ZUNI BOWL



Schematic of Zuni Bowl from Erosion Control Field Guide, Quivira Coalition & Watershed Artisans

ADAPTATIONS & MAINTENANCE

While we described the typical shape of a Zuni Bowl, shapes may vary to fit the landscape. Replace and secure rocks that dislodge from the structure after high flows. Seeding the structure can promote seed growth and the establishment of vegetation.

CRITICAL CONSTRUCTION AND DESIGN ELEMENTS

The rocks must be arranged such that water falls off and onto rocks rather than the ground to prevent further erosion. Zuni Bowls up to 3 ft in height can be built by hand using 10 - 50 lb rocks, however, anything larger may require assistance from heavy equipment. Each layer of rock should be supported enough by the rocks below so they lean into and are partially supported by the banks. Angular rocks should be used so they lock into each other.

- https://www.youtube.com/watch?v=QS8HertuStE

ONE ROCK DAM

One Rock Dam constructed by HPWA seasonal crews in Gallinas (Summer 2023).

DESCRIPTION AND PURPOSE

A **One Rock Dam (ORD)** is an in-channel grade control structure composed of many rocks arranged one rock high. ORDs are not dams because water flows over them. ORDs stabilize the channel and prevent channel erosion, especially downcutting, by slowing the flow of water, increasing roughness, and capturing sediment. The accumulation of sediment raises the channel bed, reconnecting it to its floodplain (allowing floodwaters to spill out of the channel), and helping to raise the water table. Newly collected sediment helps establish a seedbed for new plant growth.

APPROPRIATE LOCATIONS

One Rock Dams are typically built in ephemeral stream channels and gullies less than 15 feet in width. It is best to use large rocks, tree stumps, or the banks to anchor these structures to avoid structure disassembly during high flow events. ORDs may not be appropriate in areas with a steeper slope as water velocities are often too high and structures are easily compromised.

CONSTRUCTION PROCESS

Step 1: Level the area you are going to build the structure and remove any loose rock and debris from the channel.

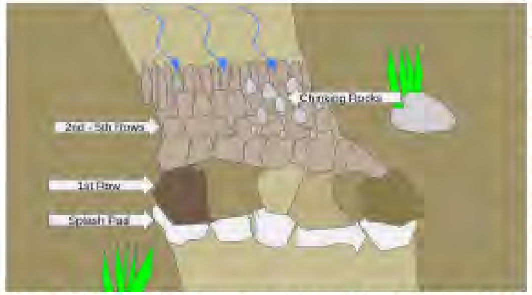
ONE ROCK DAM

CONSTRUCTION PROCESS (CONTINUED)

Step 2: Dig a shallow trench at the downstream end of the structure, perpendicular to the channel and spanning the entire channel width. Lay large, flat rocks interlocking in the trench so that no rock protrudes more than 2 inches above the bed of the channel. This first layer of rocks is called the **footer** or **splash pad**. This first row should extend up the side slopes to prevent water from going around the edge of the structure. The footer helps prevent undermining the structure during high flows.

Step 3: Arrange a row of rocks overlapping ⅔ of the splash pad across the channel. If possible, arrange this second row in a ***"book stacking"*** manner for extra strength and stability. Use flatter rocks for this.

Step 4: Arrange an additional 4+ rows of interlocking rocks directly behind the second row (in the upstream direction). These rows could be book-stacked but that isn't necessary. As you approach the final rows, the rocks should gradually decrease in height.



Step 5: Fill buckets with smaller, gravel-like rocks and empty them onto the structure to fill gaps. This process is known as **chinking**, and has proven to play a role in the stability and effectiveness of the structure.

Step 6: Test the structure by walking across it. Notice any rocks that may move out of place and need to be adjusted or replaced.


ONE ROCK DAM

ADAPTATIONS & MAINTENANCE

Some work sites may have few available rocks. In these cases, sandbags filled with local dirt and seeds inside on the upper surface can be used in place of rocks, following the same design concept. An ORD-like structure can also be built with logs (see the Log Step Down and Log Mat structures in the following pages). Seeding the structure may encourage plant growth to help with stability. After several high-flow events, sediment should accumulate on top and upstream of the ORD. The goal is that the channel aggrades (build-up) until it is connected to the floodplain. In more entrenched channels, you may increase the height of the ORD to further build up the channel by adding another layer of rocks on top starting at the second row of the existing structure. The original ORD becomes the splash pad for the new layer. With high-flow events, rocks may be dislodged from the ORD. In this case, you should reposition them or replace them with larger, rocks.

CRITICAL CONSTRUCTION AND DESIGN ELEMENTS

The rocks should decrease in size as you reach the final rows, so that they level out with the channel bed. Rock size will vary depending on the depth of the channel, but should be about 1/3 the depth of the defined channel. The splash pad should be large enough to prevent scour from water running over the structure and missing the splash pad. It is important that all rows extend up the side slopes to prevent water from going around the edges of the structure. ORDs should be placed in straight sections of the channel, or the cross over. Many of them can be built in a sequence or paired with other structures.

Materials: Evaluation of Onsite Rocks/ Ordering Rocks from a Supplier

MATERIAL:	CLASS B RIP RAP 12-18"	PROJECT No.:	VARIOUS
DATE:	11/29/23	LAB No.:	HP-33
SOURCE PIT:	CALDWELL PIT	SAMPLE DATE:	11/27/23
PRODUCT CODE:	522	REPORT DATE:	11/27/23
AGENCY SPECIFICATION:	ASTM	SAMPLED BY:	J. BALLARD
PRODUCT DESCRIPTION:	12-18"	REVIEWED BY:	E.AAMOLD

REPORT OF AGGREGATE PHYSICAL PROPERTIES

SIEVE ANALYSIS		
ASTM C136		BAND
Sieve Size	% Passing	
450 mm (18")	95	
375 mm (15")	86	
300 mm (12")	51	
250 mm (10")	44	
225 mm (9")	30	
200 mm (8")	9	
150 mm (6")	3	
125 mm (5")	2	
100 mm (4")	1	
75 mm (3")	1	
63 mm (2-1/2")	1	
50 mm (2")	1	
37.5 mm (1-1/2")	1	
25 mm (1")	1	
19 mm (3/4")	1	
12.5 mm (1/2")	1	
9.5 mm (3/8")	1	
6.3 mm (1/4")	1	
4.75mm (No.4)	1	
2.36mm (No. 8)	1	
2.00mm (No. 10)	1	
1.18mm (No. 16)	1	
0.600mm (No. 30)	1	
0.425mm (No. 40)	1	
0.300mm (No. 50)	1	
0.180mm (No. 80)	1	
0.150mm (no. 100)	1	
0.075mm (No. 200)	0.2	
ASTM C117		
MOISTURE CONTENT, %	0.5%	
ASTM C566		
FRACTURED FACE, %	100%	

TEST RESULTS					
STANDARD	PHYSICAL PROPERTIES		RESULTS	SPECIFICATION	LAB OF RECORD
ASTM C131	LA ABRASION	SMALL COARSE LOSS, %=	24.8%	40 MAX	
		GRADING/ REVS.=	500		
	NMDOT AGGREGATE INDEX	COARSE AGGREGATE, %=	11.0		
ASTM C88	SOUNDNESS	COARSE SOUNDNESS LOSS, %=	2.26%	15 MAX	
		MAGNESIUM No. OF CYCLES	500		
	SOUNDNESS	FINE SOUNDNESS LOSS, %=	11.0	<25	
		MAGNESIUM No. OF CYCLES	5		
ASTM C142	CLAY/FRIABLE PARTICLES	COARSE AGGREGATE, %=	0.10%	2.0 MAX	
		FINE AGGREGATE, %=	0.40%		
ASTM D4318	LIQUID LIMIT, PLASTIC LIMIT & PLASTICITY INDEX	LIQUID LIMIT=	SNP		
		PLASTIC LIMIT=	SNP		
		PLASTICITY INDEX=	SNP	6 MAX	

NOTES:

MATERIAL:	RIP RAP CLASS A 4-8	PROJECT No.:	VARIOUS
DATE:	11/29/23	LAB No.:	HP-9
SOURCE PIT:	CALDWELL PIT	SAMPLE DATE:	11/27/23
PRODUCT CODE:	521	REPORT DATE:	11/27/23
AGENCY SPECIFICATION:	NMDOT	SAMPLED BY:	J. BALLARD
PRODUCT DESCRIPTION:	4-8"	REVIEWED BY:	E. AAMOLD

REPORT OF AGGREGATE PHYSICAL PROPERTIES

SIEVE ANALYSIS		
ASTM C136		BAND
Sieve Size	% Passing	
450 mm (18")		
375 mm (15")	100	
300 mm (12")	100	
250 mm (10")	100	
225 mm (9")	97	
200 mm (8")	86	
150 mm (6")	42	
125 mm (5")	20	
100 mm (4")	2	
75 mm (3")	2	
63 mm (2-1/2")	2	
50 mm (2")	1	
37.5 mm (1-1/2")	1	
25 mm (1")	1	
19 mm (3/4")	1	
12.5 mm (1/2")	1	
9.5 mm (3/8")	1	
6.3 mm (1/4")	1	
4.75mm (No.4)	1	
2.36mm (No. 8)	1	
2.00mm (No. 10)	1	
1.18mm (No. 16)	1	
0.600mm (No. 30)	1	
0.425mm (No. 40)	1	
0.300mm (No. 50)	1	
0.180mm (No. 80)	1	
0.150mm (no. 100)	1	
0.075mm (No. 200)	0.1	
ASTM C117		
MOISTURE CONTENT, %	0.5%	
ASTM C566		
FRACTURED FACE, %	100%	

TEST RESULTS					
STANDARD	PHYSICAL PROPERTIES		RESULTS	SPECIFICATION	LAB OF RECORD
ASTM C131	LA ABRASION	SMALL COARSE LOSS, %=	24.8%	40 MAX	
		GRADING/ REVS.=	500		
	NMDOT AGGREGATE INDEX	COARSE AGGREGATE, %=	11.0		
ASTM C88	SOUNDNESS	COARSE SOUNDNESS LOSS, %=	2.26%	15 MAX	
		MAGNESIUM No. OF CYCLES	500		
	SOUNDNESS	FINE SOUNDNESS LOSS, %=	11.0	<25	
		MAGNESIUM No. OF CYCLES	5		
ASTM C142	CLAY/FRIABLE PARTICLES	COARSE AGGREGATE, %=	0.10%	2.0 MAX	
		FINE AGGREGATE, %=	0.40%		

NOTES:

AGGREGATE:	
Crushed Fines	ID: 530
3/8" Crushed Gravel	ID: 508 #8
1/2" Crushed Gravel	ID: 557 #57
3/4" Crushed Gravel	ID: 506 #6
7/8" Crushed Gravel	ID: 556 #56
1.5" Crushed Gravel	ID: 504 #4
2-4" Crushed Gravel	ID: 501 #1
6" Rip Rap	ID: 528
Class A Rip Rap 4 - 8"	ID: 521
Class B Rip Rap 12 - 18"	ID: 522
Class C Rip Rap 18 - 24"	ID: 523
Class D Rip Rap 24 - 36"	ID: 524
Class E Rip Rap 4 - 12"	ID: 525
Class F Rip Rap 12 - 18"	ID: 526
Class G Rip Rap 4' - 8"	ID: 528
Rip Rap 5 - 12"	ID: 520
Boulder Misc.	ID: 529
Engineer - Fill Dirt	ID: 531
NMDOT Type 1 Base Course	ID: 591
NMDOT Type 2 Base Course	ID: 592
COA Type 2 Base Course	ID: 594

Safety

Hand/finger injury from rocks. This is the most common injury experienced on AWF restoration projects. When placing a rock in a rock structure, fingers or hands can become caught between or underneath the rocks and injured.	Volunteers are asked to: • Wear gloves. • Work slowly and carefully when placing rocks, and use special care when working in close quarters with other volunteers. • Report any injury promptly to the project lead or another AWF or project partner leader on site. AWF will have a first aid kit available at the project site for all projects and will identify leaders who have medical training and are available to assist in dealing with any injuries that occur during a project.
Foot/leg injury from rocks. The most serious injuries experienced on past AWF projects have been caused by rocks being dropped on feet or legs. This can lead to bruising, crush injury, or broken bones.	Volunteers are asked to: • Wear long pants and protective footwear, including sturdy closed toe shoes. • Work slowly and carefully when placing rocks, and use special care when working in close quarters with other volunteers. • Report any injury promptly to the project lead or another AWF or project partner leader on site. AWF will have a first aid kit available at the project site for all projects and will identify leaders who have medical training and are available to assist in dealing with any injuries that occur during a project. If a serious injury occurs, the volunteer should be evacuated to seek medical attention. AWF leaders will assist in transporting a volunteer if needed.

Safety (cont.)

Injury from tools or equipment. Tools and equipment can cause injury in a variety of ways. If they are not carried properly, a shovel or other long-handled tool can strike another person. Tools like pickaxes can strike someone standing behind the person using the tool. Shovels used improperly (such as by jumping on them) can cause foot and leg injury. Wheelbarrows can be unsteady when filled with a heavy load, like rocks, and may tip over and fall on someone.	Volunteers are asked to: • Wear gloves and protective footwear, including sturdy closed toe shoes. • Carry tools safely and carefully. Most tools, especially long tools, should be carried to one's side. • Do not use a tool unless you know how to use it safely. • Do not use a broken tool or one with a loose handle. • Be aware of others working around you, and look around for other people and hazards before swinging tools. • Have firm footing and good balance when swinging a tool. • Report any injury promptly to the project lead or another AWF or project partner leader on site. AWF will have a first aid kit available at the project site for all projects and will identify leaders who have medical training and are available to assist in dealing with any injuries that occur during a project.

Injury from lifting. Lifting a rock or other heavy object can strain muscles or cause back injury.	Volunteers are asked to: • Use proper lifting techniques when picking up items: bend knees, not back; lift straight. • Know your limits and do not lift anything that is too heavy for you to carry safely. • Stretch periodically. • Work with a partner to lift heavy objects, ideally using a tool like a rock litter.

Moving Rocks and Sediment

- Fabric litter
- Rock bar/digging bar
- Pick-mattock
- Shovels
- McCloud/Fire Rake
- Five-gallon bucket
- Wheelbarrow
- Gravity

Using Tools

Moving Rocks

Moving Sediment

Santa Fe Botanical Gardens Field Trip

Walking distance - .3 miles each way

km

Appendix F. Watershed Restoration Field Guide

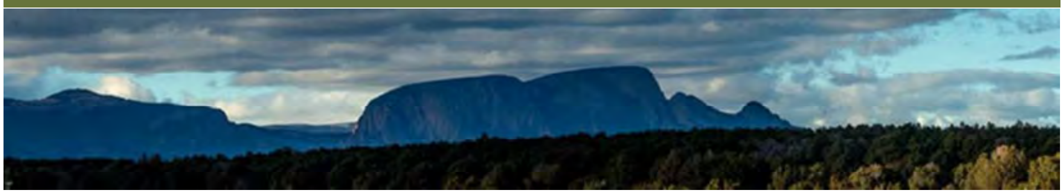
HERMIT'S PEAK
WATERSHED ALLIANCE

WATERSHED RESTORATION FIELD GUIDE

POST-FIRE RESTORATION EDITION

TABLE OF CONTENTS

INTRODUCTION

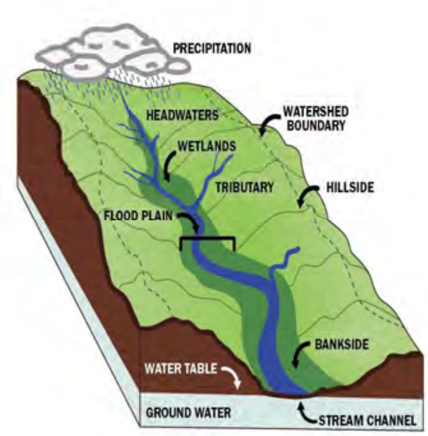


WHO IS HERMIT'S PEAK WATERSHED ALLIANCE?

The Hermit's Peak Watershed Alliance (HPWA) is a local 501(c3) non-profit organization formed in 2009. We work to protect and restore the ecological and cultural heritage of watersheds in the Hermit's Peak region through ecological restoration, environmental education and community action. Our work occurs over a 1,500 square mile area in NE New Mexico covering the Gallinas, Sapello, Tecolote, and lower Mora Watersheds. We assess and monitor conditions to identify watershed health problems, then help improve watershed management and do restoration to address degradation. Our current focus is on post-fire watershed recovery. Educating and guiding landowners, decision makers, and our next generation is also a significant part of HPWA's work. Our work, relevant to this guide, includes construction of low-tech, land and water restoration structures to heal a legacy of degradation and recover from severe natural disturbances like fire and flood.

WHAT IS A WATERSHED?

A **watershed** is an area of land that drains water into a specific body of water, like a river, lake or ocean. Rain or snow that falls in a watershed travels downhill on the surface or underground, providing a water supply to support the entire area. A watershed includes soil, topography, water, air, plants, animals, and people. Watersheds provide many other services to the land and its inhabitants including water distribution over time and space, water filtration and storage, as well as fire, flood, and drought mitigation.



WHAT IS WATERSHED RESTORATION?

Watershed restoration strives to rebuild the natural structures, processes and functions of land and water ecosystems. With restoration and thoughtful management, healthy watersheds can perform many services needed by people without significant intervention. Watershed restoration done by HPWA and many others is low-tech using local materials (rocks, logs, soil and plants) and mimicking features found in nature. After the 2022 Hermit's Peak - Calf Canyon Fire, HPWA hit the ground running and constructed hundreds of low-tech structures. Each structure is designed to prevent\arrest land or water drainage erosion, sequester sediment and debris, and reduce damage caused by high water flows. Restoration structures emulate natural processes that were disrupted or changed as a result of the fires and subsequent floods.

PURPOSE

The purpose of this document is to guide restoration of small drainage channels. These include channels that only flow after storm events (ephemeral streams) or during a particular season like during spring snowmelt or the monsoon season (intermittent streams). These drainage channels include arroyos and swales.

In this guide, you will **learn about the purpose of each structure with instructions on how and where to build them including some design considerations.** Structures in this guide are those built by hand using onsite materials such as rocks and logs.

One Rock Dam constructed by HPWA seasonal crews in Sapello before (left) and after (right) filling up with sediment (Summer 2023).

The structures in this Guide are foundational. There are however other structures and these structures have many other customized forms to adjust to a given situation. The land and water drainages are all different and these foundational structures often need to be modified to fit that variation. These structures do offer tried and true models and the way they work needs to be considered when developing custom structures.

There are many other important practices and techniques to do watershed restoration, like revegetation, but they are covered in other documents.

This Guide is supported by a series of videos being developed by HPWA. The first is an introduction to watershed impacts from severe fire and the video that follows this specific guide can be found on our website at: www.hermitspeakwatersheds.org

ROCK STRUCTURES

WHY BUILD STRUCTURES WITH ROCKS?

The following structures are constructed by gathering and arranging rocks of various shapes and sizes into interlocking patterns. There are many benefits to using rocks to build restoration structures, one being they are plentiful in many remote settings. Another is rocks are naturally occurring on the landscape unlike concrete or other man made materials and provide a long-term element that doesn't need to be removed later. Using local rocks reduces restoration costs and fossil fuels to transport materials. Some rocks are quite massive which can provide structural stability and strength.

Since there are many different shapes and sizes of rocks, they each perform a unique function. Larger rocks act as support or anchors whereas smaller rocks may be used to fill gaps between the larger ones (known as **chinking**). Rocks that have a relatively flat surface are perfect for the foundation of certain structures.

Safety Note: The most common injury when working with rocks is hitting or crushing your body parts. Always be aware of your body position and surroundings when moving rocks. Some rocks may be housing wildlife beneath them (ex. snakes, lizards, spiders) so try not to disturb them or put yourself in harms way. When rolling large rocks downhill, always call out "Rock" so crew members are aware.

ONE ROCK DAM

One Rock Dam constructed by HPWA seasonal crews in Gallinas (Summer 2023).

DESCRIPTION AND PURPOSE

A **One Rock Dam (ORD)** is an in-channel grade control structure composed of many rocks arranged one rock high. ORDs are not dams because water flows over them. ORDs stabilize the channel and prevent channel erosion, especially downcutting, by slowing the flow of water, increasing roughness, and capturing sediment. The accumulation of sediment raises the channel bed, reconnecting it to its floodplain (allowing floodwaters to spill out of the channel), and helping to raise the water table. Newly collected sediment helps establish a seedbed for new plant growth.

APPROPRIATE LOCATIONS

One Rock Dams are typically built in ephemeral stream channels and gullies less than 15 feet in width. It is best to use large rocks, tree stumps, or the banks to anchor these structures to avoid structure disassembly during high flow events. ORDs may not be appropriate in areas with a steeper slope as water velocities are often too high and structures are easily compromised.

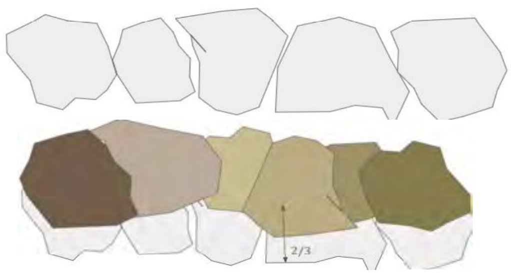
CONSTRUCTION PROCESS

Step 1: Level the area you are going to build the structure and remove any loose rock and debris from the channel.

ONE ROCK DAM

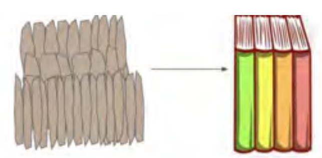
CONSTRUCTION PROCESS (CONTINUED)

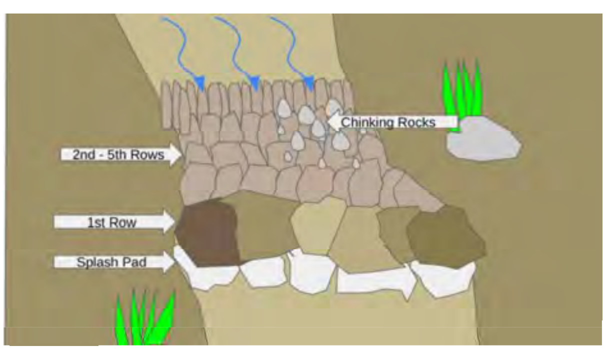
Step 2: Dig a shallow trench at the downstream end of the structure, perpendicular to the channel and spanning the entire channel width. Lay large, flat rocks interlocking in the trench so that no rock protrudes more than 2 inches above the bed of the channel. This first layer of rocks is called the **footer** or **splash pad**. This first row should extend up the side slopes to prevent water from going around the edge of the structure. The footer helps prevent undermining the structure during high flows.



Step 3: Arrange a row of rocks overlapping ⅔ of the splash pad across the channel. If possible, arrange this second row in a **“*book stacking*”** manner for extra strength and stability. Use flatter rocks for this.

Step 4: Arrange an additional 4+ rows of interlocking rocks directly behind the second row (in the upstream direction). These rows could be book-stacked but that isn’t necessary. As you approach the final rows, the rocks should gradually decrease in height.

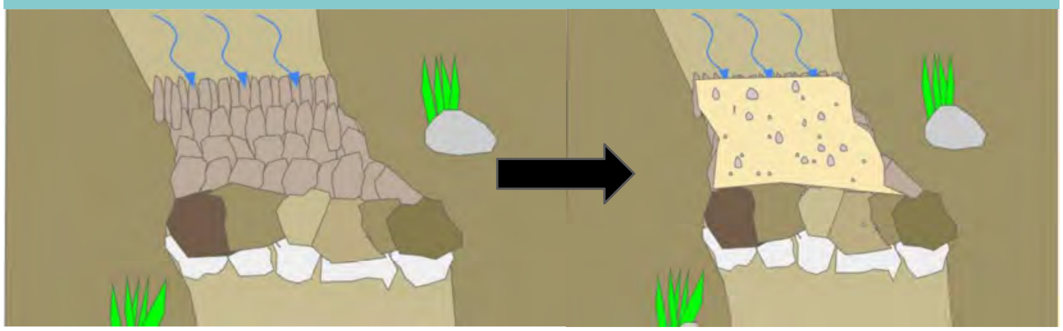




Step 5: Fill buckets with smaller, gravel-like rocks and empty them onto the structure to fill gaps. This process is known as **chinking**, and has proven to play a role in the stability and effectiveness of the structure.

Step 6: Test the structure by walking across it. Notice any rocks that may move out of place and need to be adjusted or replaced.

ONE ROCK DAM



ADAPTATIONS & MAINTENANCE

Some work sites may have few available rocks. In these cases, sandbags filled with local dirt and seeds inside on the upper surface can be used in place of rocks, following the same design concept. An ORD-like structure can also be built with logs (see the Log Step Down and Log Mat structures in the following pages). Seeding the structure may encourage plant growth to help with stability. After several high-flow events, sediment should accumulate on top and upstream of the ORD. The goal is that the channel aggrades (build-up) until it is connected to the floodplain. In more entrenched channels, you may increase the height of the ORD to further build up the channel by adding another layer of rocks on top starting at the second row of the existing structure. The original ORD becomes the splash pad for the new layer. With high-flow events, rocks may be dislodged from the ORD. In this case, you should reposition them or replace them with larger, rocks.

CRITICAL CONSTRUCTION AND DESIGN ELEMENTS

The rocks should decrease in size as you reach the final rows, so that they level out with the channel bed. Rock size will vary depending on the depth of the channel, but should be about 1/3 the depth of the defined channel. The splash pad should be large enough to prevent scour from water running over the structure and missing the splash pad. It is important that all rows extend up the side slopes to prevent water from going around the edges of the structure. ORDs should be placed in straight sections of the channel, or the cross over. Many of them can be built in a sequence or paired with other structures.

ROCK RUN DOWN

Rock Rundown constructed by HPWA seasonal crew in Sapello (Summer 2023).

DESCRIPTION & RESTORATION PURPOSE

Rock Rundowns are used to stabilize low energy **head-cuts** in channels with a gentle slope by lining the channel with rocks. They prevent further erosion by slowing fast moving water, reducing erosive energy, and retaining moisture between rocks, encouraging plant growth.

APPROPRIATE LOCATIONS

Rock Rundowns are typically used to repair low-energy head-cuts less than 2 ft. in height, larger head-cuts may require a different structure (*ex. Zuni Bowl)*. They are appropriately constructed on moderate to gentle slopes. Rock Rundowns are usually constructed in upland areas where head-cuts are forming. They can be built in small watercourses with gentle slopes (ex. arroyos).

CONSTRUCTION PROCESS

Step 1: Pick an appropriate site for structure construction.

ROCK RUN DOWN

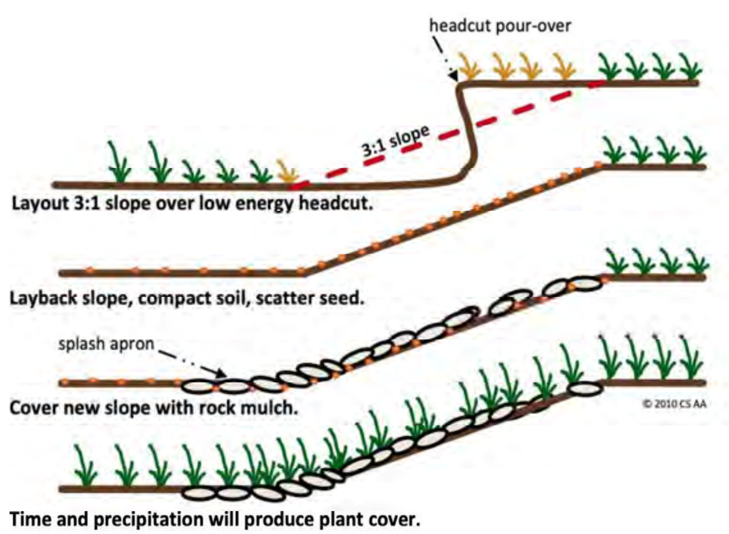
CONSTRUCTION PROCESS (CONTINUED)

Step 2: Prepare the site by gathering (staging) building materials and leveling the surface of the channel by removing the lip of the head-cut, and removing loose rocks or debris. You should leave large flat rocks in place and incorporate them into the structure.

Step 3: Arrange large, flat-ish rocks on the bed of the channel, flipping and rotating them as needed to achieve an interlocking mosaic pattern. The rocks at the upstream/uphill end should completely cover the head-cut. Continue placing rocks until the desired length is reached.

Step 4: Fill any gaps between rocks with chinking.

Step 5: Test the structure's integrity by walking across it. Notice any rocks that may move out of place and need to be adjusted or replaced.



Schematic of Rock Rundown from Erosion Control Field Guide, Quivira Coalition & Watershed Artisans
© 2012 CS AA

ROCK RUN DOWN

Rock Rundown constructed by HPWA seasonal crews in Sapello (Summer 2023).

ADAPTATIONS & MAINTENANCE

You may seed the structure to promote seedbed establishment and natural plant succession. It is possible to construct a Rock Rundown with sandbags or logs (see Log Mat in the following pages if rocks are scarce or absent at a particular site).

CRITICAL CONSTRUCTION AND DESIGN ELEMENTS

Rocks should be heavy enough so that water is unable to move them out of the structure. Though Rock Rundowns are one of the more basic structures, they are more than just rocks thrown in the channel. Rocks should be placed neatly and interlocked so high-flow events cannot displace them. Using rocks that are too round (river rock) are not as stable as angular rocks.

MEDIA LUNA

Media Luna constructed by HPWA seasonal crews in Sapello (Summer 2023).

DESCRIPTION & RESTORATION PURPOSE

A Media Luna is a crescent-shaped rock structure used in upland situations to prevent erosion. It redirects sheet (surface) flow by moving it away from a newly forming head-cut or erosive area. It can also redirect dispersed flow into a defined channel or wetland to keep these areas wet. Depending on how the structure is arranged **(tips up or tips down)**, it manages sheet flow by dispersing erosive runoff to a larger depositional area, or it prevents erosion and maintains wetted areas by creating a gradual transition from sheet flow to channel flow.

APPROPRIATE LOCATIONS

A Media Luna works well in slope wetlands, alluvial fans, or gentle to moderate upland slopes that are experiencing erosive sheet flow. They are built on relatively flat areas and not in a stream channel. In locations with numerous rills, broadscale erosion can be reduced by collecting flow in one channel with a tips-down media luna. In locations where erosion is creating defined channels and head-cuts, flow can be dispersed away from new forming channels with a tips-up media luna.

CONSTRUCTION PROCESS

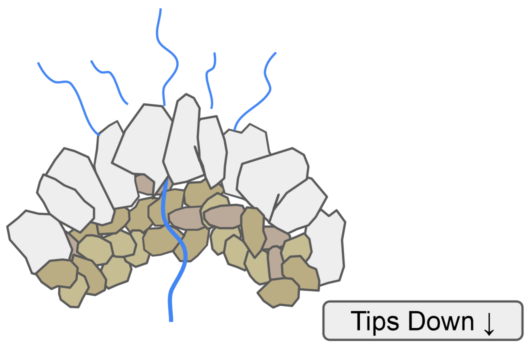
Step 1: Pick an appropriate site for construction, considering the slope, sheet flow velocity and water volume. The structure should be built on relatively flat ground.

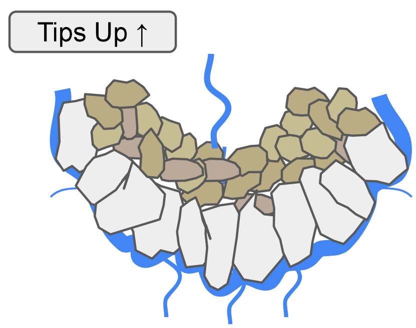
MEDIA LUNA

CONSTRUCTION PROCESS (CONTINUED)

Step 2: Prepare the site by gathering (staging) building materials and leveling the surface by removing loose rocks or debris.

Step 3: Arrange the first row of the crescent with large, flattish rocks in a lunate (half-moon) shape across the surface. For a sheet flow collector, arrange the structure in a tips-down formation. Inversely, a sheet flow disperser is arranged with tips up.





Step 4: Continue placing rocks to extend the crescent shape until the desired shape is achieved, filling any gaps between rocks by chinking.

Step 5: Test the structure's integrity by walking across it. Notice any rocks that may move out of place and need to be adjusted or replaced.

MEDIA LUNA

Media Luna constructed of logs by HPWA seasonal crews (Summer 2023).

ADAPTATIONS & MAINTENANCE

You may seed the structure to promote seedbed establishment and natural plant succession. It is possible to construct a Media Luna with sandbags, straw bales, or logs if rocks are scarce or absent at the site. If high flows displace any rocks, use larger rocks and secure them properly.

CRITICAL CONSTRUCTION AND DESIGN ELEMENTS

Rocks should be heavy enough so water is unable to move them out of the structure. A Media Luna should be built on relatively flat ground to avoid further erosion.

ZUNI BOWL

Zuni Bowl constructed by HPWA seasonal crews in Sapello (Fall 2023).

DESCRIPTION & RESTORATION PURPOSE

The Zuni Bowl is an in-channel head-cut control structure that was first observed and developed by Bill Zeedyk and the people of the Zuni Pueblo in New Mexico. The Zuni Bowl uses the principles of step-pools and natural cascades to dissipate the energy of water falling from the pour-over of a head-cut. This stabilizes the head-cuts by creating two or more subtle falls to replace the fall from the original head-cut that is usually actively eroding. If successful, the structure will also allow better retention of moisture in the bowl and below the head-cut, promoting vegetation growth.

APPROPRIATE LOCATIONS

Head-cuts under 3ft in height can be addressed by a hand-built Zuni Bowl. Zuni Bowls in head-cuts greater than 3 ft in height may require assistance from heavy equipment and large rocks. Some treatment areas may already have a bowl-like shape or large boulders to incorporate into the structure.

CONSTRUCTION PROCESS

Step 1: Start by selecting an appropriate head-cut to address. Shape and lay back the face of the head-cut to create a uniform surface on which to build. Level the base of the head-cut and below where the basin will be built by removing loose material (rocks, roots, etc.) and other irregularities.

ZUNI BOWL

CONSTRUCTION PROCESS (CONTINUED)

Step 2: Gather and stage rocks of varying shapes and sizes, selecting many large, angular and flat rocks.

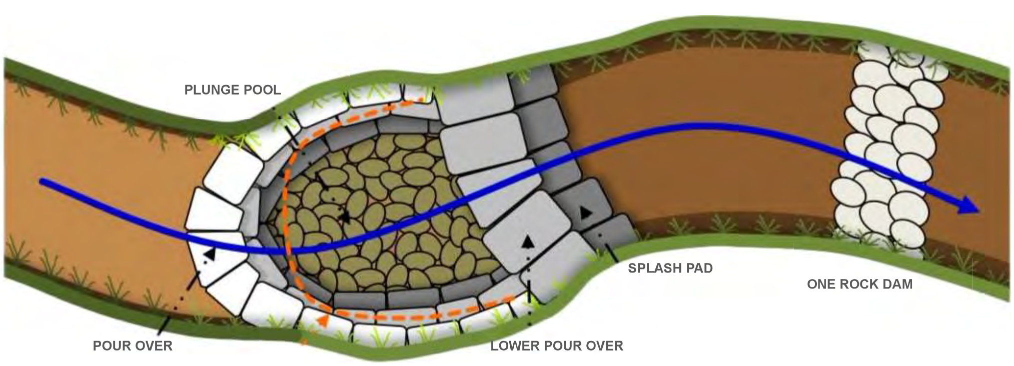
Step 3: Line the base (downstream end) of the Zuni Bowl with large, flatter rocks to create a splash pad for the structure.

Step 4: Arrange the next row of rocks overlapping ⅔ the splash pad. These rocks should sit at an elevation approximately 1/2 the total height of the headcut if possible.This will form the lower pour over of the bowl.

Step 5: Line the bottom of the basin of the structure with rocks to create the plunge pool. Continue stacking rocks up to the height of the headcut. Be careful not to build above this height. This forms the walls of the bowl.

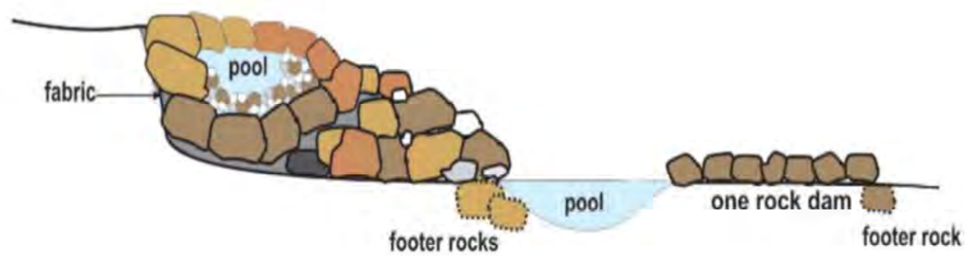
Step 6: Continue arranging rocks until the desired rock basin shape is achieved, filling any gaps water could potentially move through.

Step 7: Construct an *ORD* downstream from the Zuni Bowl. Place the upstream edge of the ORD approximately six to eight times (6-8x) the height of the headcut away from the Zuni Bowl pour-over.



Schematic of Zuni Bowl from Erosion Control Field Guide, Quivira Coalition & Watershed Artisans

ZUNI BOWL



Schematic of Zuni Bowl from Erosion Control Field Guide, Quivira Coalition & Watershed Artisans
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ADAPTATIONS & MAINTENANCE

While we described the typical shape of a Zuni Bowl, shapes may vary to fit the landscape. Replace and secure rocks that dislodge from the structure after high flows. Seeding the structure can promote seed growth and the establishment of vegetation.

CRITICAL CONSTRUCTION AND DESIGN ELEMENTS

The rocks must be arranged such that water falls off and onto rocks rather than the ground to prevent further erosion. Zuni Bowls up to 3 ft in height can be built by hand using 10 - 50 lb rocks, however, anything larger may require assistance from heavy equipment. Each layer of rock should be supported enough by the rocks below so they lean into and are partially supported by the banks. Angular rocks should be used so they lock into each other.

BAFFLE

Baffle constructed by HPWA seasonal crews in Gallinas (Summer 2023).

DESCRIPTION & RESTORATION PURPOSE

The Baffle is an in-channel structure, usually composed of large rocks arranged in a triangular design. The purpose of a baffle is to induce meandering by diverting water flow from one side of the channel to the opposite side. This structure can also be used to deflect water flow away from eroding slopes that are jeopardizing important features. Baffles can create **point bars** or areas where sediment collects on one side of the bank, which provides stability to riparian habitats.

APPROPRIATE LOCATIONS

Baffles are most effective in influencing sinuosity in small channelized streams, preventing downcutting and further erosion. As with other structures, it is best to build a baffle in an area that incorporates natural structural elements such as large boulders or tree stumps and roots.

CONSTRUCTION PROCESS

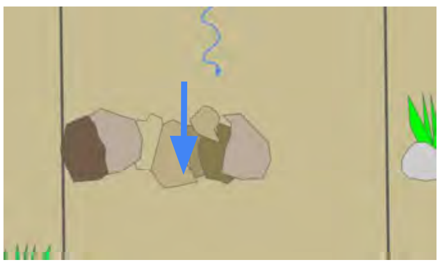
Step 1: Pick an appropriate site for construction.

Step 2: Prepare the site by gathering (staging) building materials and leveling the surface of the channel by removing loose rocks or debris.

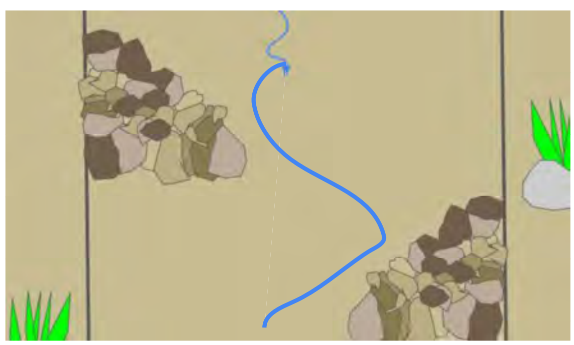
BAFFLE

CONSTRUCTION PROCESS (CONTINUED)

Step 3: Arrange the first row of rocks perpendicular to the downstream bank at a distance of ½ the channel width. This creates the base and tip of the baffle.



Step 4: From the base tip of the baffle, move upstream, placing rocks in rows that become narrower the farther upstream you move. The distance from the base of the baffle to the upstream end will be 1.5 times the channel width.



Step 5: Repeat the process above to construct a baffle downstream on the opposite side of the channel. This will induce meandering.

Step 6: Fill any gaps between rocks by chinking both structures.

Step 7: Test the structure's integrity by walking across it. Notice any rocks that may move out of place and need to be adjusted or replaced.

BAFFLE

Baffle constructed by HPWA seasonal crews in Sapello (Summer 2023).

ADAPTATIONS & MAINTENANCE

If rocks are absent, a baffle can be built using posts staked into the ground following the same design. Logs can be incorporated into a rock baffle for stability, to use available materials, and to help create the triangular shape. They can be used on either the upstream or downstream edge. Seeding newly formed point bars may help revegetation. Replace any washed-out rocks and secure them to the structure.

CRITICAL DESIGN & CONSTRUCTION ELEMENTS

Though many shapes of baffle have been built, the most effective shape was proven to be a right triangle. Rocks used in baffle construction should resist expected flood forces, however, they should be uniformly sized so that the surface of the structure is streamlined.

LOG STRUCTURES

Upper Gallinas burnt tree stands after the HPCC fires (Summer 2023).

WHY BUILD STRUCTURES WITH LOGS?

The following structures are constructed by gathering and arranging logs (and rocks) of various lengths and diameters to control erosion, sequester sediment, or reduce flow velocities in small channels. Like rocks, there are many benefits to using logs to build restoration structures, one being they are plentiful in most remote settings and especially after a fire. Restoration structures are an excellent use of dead or burned trees, giving them a meaningful purpose. Another benefit to using logs is they are biodegradable and will decay and become nutrients for new soil biotic activity. Logs are also heavy and if placed properly are not likely to move out of position.

Safety Note: Always be aware of your surroundings near the sawyer. A chainsaw is a useful tool but can be dangerous if you are not careful. Always let an experienced sawyer fell trees. Some trees may have branches that fall off as a result of vibrations from chainsaws or even the wind. Listen for the sawyer to call out “Falling!” or “Back cut!” so you can move out of the path of the falling tree.

LOG MAT

Log Mat to stabilize a channel side slope constructed by HPWA seasonal crews (Summer 2023).

DESCRIPTION & RESTORATION PURPOSE

A Log Mat is an erosion control structure built by arranging logs in a single layer in the bed or on the edge of a channel. They line the bed of incised channels to trap sediment, raising the elevation of the channel bed. They also help arrest erosion on the channel sides. Similar to the function of ORDs, Log Mats ultimately reconnect water with the surface of the slope wetland.

APPROPRIATE LOCATIONS

Log Mats work best in successive cross-over segments of incised channels. They are useful in areas where a head-cut is forming in a newly forming channel, in uplands, or wetlands.

CONSTRUCTION PROCESS

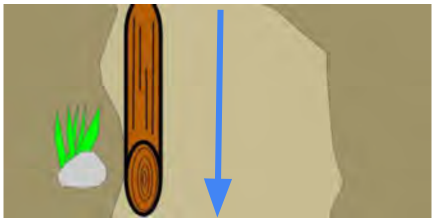
Step 1: Pick an appropriate site for construction.

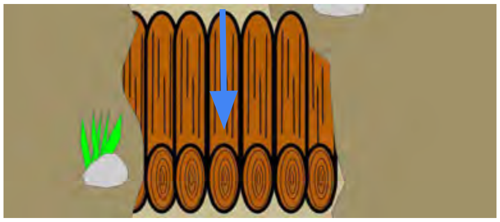
LOG MAT

Step 2: Prepare the site by leveling the surface of the channel by removing rocks or debris.

Step 3: Communicate with the sawyer to fall trees and cut them into logs of a similar length.

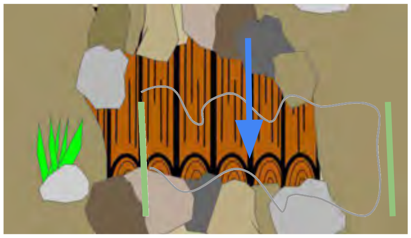
Step 4: Place logs in a single row across the channel, parallel to the direction of flow. You may need to rotate logs and cut off any sharp edges to make them fit snugly. Fill any gaps between logs by chinking with rocks and branches.





Step 5: Wire the logs together using staples to attach each log to the wire. This will prevent logs from washing out in flood events. This and the next step may not be necessary in tight channels.

Step 6: Drive T-posts into the ground adjacent to the structure, then secure the logs to the posts with wire.



Step 7: Armor the sides, upstream, and downstream end of the structure with large rocks for additional support.

Step 8: Test the structure's integrity by walking across it. Notice any logs that may move out of place and need to be adjusted or replaced.

LOG MAT

Log Mat constructed by HPWA and FSG seasonal crews in Sapello (Summer 2023).

ADAPTATIONS & MAINTENANCE

Once the logs have captured enough sediment to raise the channel bed elevation, a second layer may be added to the structure, however, the second layer should be offset upslope and half the length of the Log Mat. Seeding the structure will help establish a new seed bed. Replace any washed-out logs and secure them to t-posts. **Securing the structure with t-posts and wire is optional**, however, it has proved to increase the stability of the structures we have constructed. Otherwise, use rocks and other onsite materials to anchor the structure in place.

CRITICAL CONSTRUCTION AND DESIGN ELEMENTS

It is important to get as much direct contact between the structure and the ground so water does not pass underneath the logs. Large, heavy logs should be used for Log Mats because they are less likely to wash out.

LOG STEP-DOWN

Log Step Down constructed by seasonal crews during training in Gallinas (Summer 2023).

DESCRIPTION & RESTORATION PURPOSE

A Log Step-Down is a log structure made by filling a head-cut with stacked logs. This structure uses the principle of step-falls or step-pools and is designed to create two or more drops replacing the single drop of the original head-cut. A Log Step-down can be used where a Zuni Bowl is not possible (e.g. lack of rocks).

APPROPRIATE LOCATIONS

Similarly to Zuni Bowls, Log Step-Downs work best when used in head-cuts up to 4ft in height, however, larger head-cuts may require more logs. Zuni Bowls may be built in slope wetlands as well as upland areas.

CONSTRUCTION PROCESS

Step 1: Pick an appropriate site for construction.

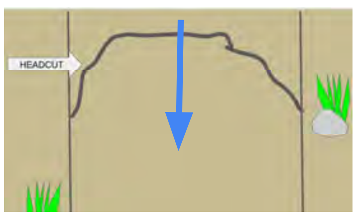
LOG STEP-DOWN

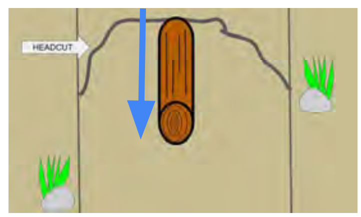
CONSTRUCTION PROCESS (CONTINUED)

Step 2: Gather and stage logs for the structure by felling trees, and cutting them to the desired size. The logs should be cut into smaller and larger lengths to achieve a cascade effect.

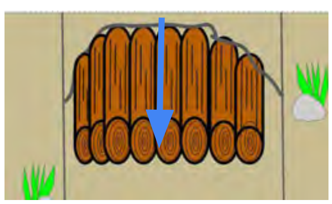
Step 3: Prepare the site by leveling the surface of the channel removing rocks, debris, and other irregularities.

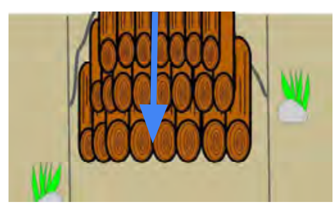
Step 4: Place the first row of logs on the channel bottom base of the head cut. These logs should be the largest and longest.





Step 5: Continue inserting rows of logs up to the top of the head cut, decreasing in length of the logs as you reach the top.





Step 6: Once you have filled the head cut with logs, you should armor the structure by placing large rocks on top of each row and also in any gaps.

Step 7: Drive t-posts on each side of the structure and cut off any additional t-post sticking out.

Step 8: Staple the wire onto the rows of logs and tie the wire to the t-posts for additional support.

LOG STEP-DOWN

Head-cut (left) formation addressed by Log Step Down (right) constructed by HPWA Seasonal Crews in Sapello (Fall 2023).

ADAPTATIONS & MAINTENANCE

It is optional to use geotextile fabric between logs and the face of the head-cut in successive layers to capture finer soil particles and retain moisture. Depending on the quality and characteristics of the log (e.g. burned vs live, Pine vs Fir) structures can function for 20 years or longer. Using T-posts to anchor the structure may prevent washout in the future. Seeding the structure will promote plant growth.

CRITICAL CONSTRUCTION AND DESIGN ELEMENTS

Log Step-Downs can be built by hand using 3 to 4 tiers of logs, however, the logs should be about 8 - 12in in diameter. The logs at the bottom of the structures should be the longest and each tier should decrease in length to achieve a step-fall design. The logs at the top tier should be slightly longer and should overlap the natural surface elevation above the edge of the head-cut so flood flows are focused towards the structure and do not go around it. The logs should be wired together and anchored in place using a minimum of four T-posts driven into the adjacent banks.

TRASH RACK

Trash Rack viewed from upstream (left) and downstream (right) in Sapello (Summer 2023).

DESCRIPTION & RESTORATION PURPOSE

A Trash Rack is a sediment and debris collection, erosion control, and flood mitigation structure composed of logs and large rocks. It is one of the most important structures to use in a post-fire situation. It is shaped like a ramp so that water rushing from upstream slows and sediment and debris are held above the structure. These structures can also aggrade or build up the channel bed, as they can collect on average 720 square feet of sediment and debris. This helps to reverse past downcutting and reconnect channels to their floodplain, helping to reduce flooding downstream. Trash racks do not act like dams, water flows through them albeit much slower.

APPROPRIATE LOCATIONS

Similar to the previous log structures, a Trash Rack is appropriate in ephemeral or small intermittent channels where downcutting or streambank erosion has occurred. They are also helpful where the side slopes are contributing sediment, logs, or rocks to the stream channel.

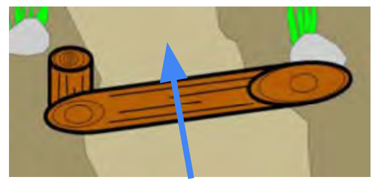
CONSTRUCTION PROCESS

Step 1: Pick an appropriate site for construction, considering channel depth.

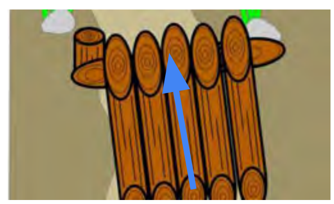
TRASH RACK

CONSTRUCTION PROCESS (CONTINUED)

<u>Step 2:</u> Fell a large tree across the channel, anchoring it to a stump or boulder on each side of the channel. This will act as a foundation or crossbeam for the rest of the structure.

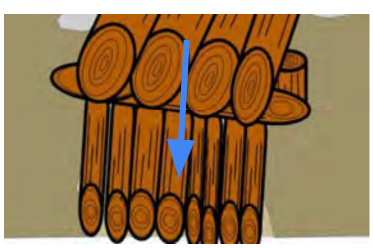


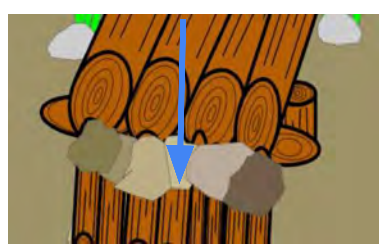
<u>Step 3:</u> Gather and stage logs for the structure by felling additional trees, and cutting them to the desired size. The logs should be long enough to rest on the cross beam of the structure, but not so long that they tip over. De-limb the logs and cut off any irregularities.



<u>Step 4:</u> Arrange the cut logs onto the crossbeam at an incline, rotating them as needed to minimize gaps between the logs.

<u>Step 5:</u> Fill any gaps between logs with smaller brush and branches**.**
Armor the bottom of the structure with large rocks if available.





<u>Step 6</u>: Place a row of logs and or rocks in front of the structure (downstream end) to prevent the formation of scour pools and undermining, this row will act as a splash pad. Fill in any gaps both upstream and downstream with rock chinking or small branches.

TRASH RACK

Trash Rack filled with sediment constructed by HPWA and FSG seasonal crews in Sapello (Summer 2023).

ADAPTATIONS & MAINTENANCE

Once the structure has collected a significant amount of sediment, another Trash Rack may be constructed either upstream or downstream from the original. Seeding the structure before sediment collects will help establish a seed bed. Seeding the collected sediment later will also help stabilize it. Logs may wash away and need to be replaced with heavier logs or at a different angle.

CRITICAL CONSTRUCTION AND DESIGN ELEMENTS

Use a large log (10” in diameter or greater) for the crossbeam to add stability. The upright logs should also be large (8-12” in diameter) for strength. Upright logs should span the entire channel, closing the gap between the edge of the channel and the rest of the structure. Logs close to the channel edge will be shorter in length. Rocks used should be large (greater than 10” in diameter) except for the chinking. When arranging the logs onto the crossbeam keep them at an angle of 45 degrees or less.

GLOSSARY OF TERMS

Aggrade - To raise the level of a river bed by the deposition of sediment.

Alluvial Fan - A cone-shaped heap of alluvium (soil, clay, silt, or gravel) deposited by flowing water, as it slows down where the slope becomes gentle. An alluvial fan usually forms where steeply sloped streams reach the valley bottom and the slope becomes less severe.

Book Stacking - Technique used to neatly stack flat rocks next to each other, resulting in increased structure strength.

Channel - The physical confinement of water drainage like a river, stream, or arroyo, consisting of a bed and banks.

Chinking - To fill the space between logs or rocks in a structure with smaller rocks or branches.

Cross Over - The straight section of a river between two meanders.

Downcutting - An erosion process that deepens a channel by removing material from a stream's bed or a valley's floor.

Entrenched - Refers to a down-cut channel that no longer has access to its floodplain during a typical storm event; often characterized by vertical banks and narrow, deep channels.

Ephemeral Stream - A stream that is usually dry, but carries water for brief periods during and after precipitation.

Floodplain - An alluvial plain adjacent to a river formed by flooding during periods of high rain.

Geotextile - A strong, permeable fabric used in structures for separation of soil layers, filtering, reinforcing, and erosion protection.

Grade - The level of the ground.

Grade Control - The practice of managing the level of the ground.

Gully/Arroyo - A trench, ravine, or narrow channel that was worn by water flow, especially on a hillside.

Head-cut - An erosional feature found in uplands or ephemeral, intermittent, or perennial streams with an abrupt vertical drop (knickpoint) in the stream bed or the land. Head-cuts start with small erosion (ex. rills) and continue to erode in an uphill or upstream direction.

Intermittent Stream - A stream that fills with water only for certain seasons (e.g., during spring snow melt, during or after monsoons), and is dry for part of the year.

Mitigation - An effort to reduce or decrease unwanted outcomes (e.g. erosion, flooding).

Perennial Stream - A stream in which water flows throughout the year, for multiple years, or all the time.

Point Bar - A ridge, formed from the collection of sand or gravel, on the inside curve of a meander.

Pour Over - The part of a structure that water spills over.

Restoration - The process of bringing a degraded landscape or water body back to a healthy state.

Rills - Very small streams of water.

Sandbags - A sturdy bag filled with local dirt, generally used as a substitution for rocks.

Sawyer - A trained individual on the crew that handles all the chainsaw work (Felling, Bucking, Cutting, etc.).

Sediment - A collection of small particles of soil that travel across the land or in a river or other body of water. Sediment usually moves by water flow and can be suspended in water.

Sinuous - Having curves in alternate directions; meandering.

Splash Pad - The part of the structure that absorbs the impact from water falling off a structure (at the pour-over), preventing scour and undermining.

Swamper - The assistant to a sawyer.

Undermining - The process of weakening something or causing it to collapse by removing its underlying support through erosion.

Watershed - An area of land where all water flows to a common outlet such as rivers, lakes, or oceans. A watershed collects water from rain, snowmelt and its runoff, and subsurface flow to a single point.

REFERENCES / ACKNOWLEDGEMENTS

THIS FIELD GUIDE CONTAINS INFORMATION FROM THE FOLLOWING SOURCES WITH PERMISSION FROM THE AUTHORS

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