# Rock Check Dams for Watershed Restoration?

Written by Dr. E. Lamar Smith, Ph.D., for the Arizona Association of Conservation Districts, March 2021

Currently there is much interest in “watershed restoration” in Arizona. Water is and will continue to be a major resource concern because Arizona is an arid state. It is generally agreed that Arizona’s watersheds are not in the best condition. Lack of effective vegetation cover results in excessive soil erosion which not only reduces productivity of the land, but also results in sediment deposits in streams and affects water quality. Lack of vegetation cover to slow runoff results in increased flooding downstream and may reduce ground water recharge. A number of treatments are used to try to restore hydrologic function on these watersheds, one of them being rock check dams. This article is intended to explain what rock check dams are, how they affect the watershed, and what are some of the considerations in their use.

Although rock check dams have been advocated and used in Arizona for some years, there appears to be relatively little actual information on how successful they have been in reaching watershed objectives. This is not really surprising because conducting research on these types of practices is difficult for several reasons, as is the case for other conservation practices. Soils, landforms, climatic conditions, vegetation, and other environmental factors vary widely, and the results obtained in one place may or may not occur in another. Because precipitation amounts and intensity vary greatly from year to year, and this affects vegetation cover, it may require many years of observation to detect whether a practice is effective or not. This is also true of research on grazing management, brush management, and some other conservation practices. In other words, the natural variability in weather may overwhelm the effect of the practice at times and thus make it hard to separate treatment effects from natural variability.

The only significant research on rock dams in Arizona that I have found is that conducted by the Agricultural Research Service (ARS) in Tucson. A very interesting photo story has been published online about this research and you are encouraged to look at it (click here). The photo story shows the dams used in the research and the changes that occurred over the life of the project. However, it does not give much detail on the measured results of the study which are described in the three publications listed on the website. Much of the discussion below is based on data and conclusions reported in those three papers.

## What Is a Rock Check Dam?

A check dam is a structure placed in a drainageway to trap sediment and slow the runoff of water, thereby reducing erosion of the drainageway. They are often seen in the borrow ditches of highways, for example. Check dams are usually small structures placed in small drainages. In larger washes or drainages, larger dams are needed; these are usually called detention dams, i.e., their function is not to impound water permanently but to store water and let it out gradually to reduce flooding downstream. Small check dams can be built of many materials such as rocks, concrete, logs, hay bales, etc. The ones discussed here are made of loose rocks and are often called loose rock dams.

Loose rock dams are designed to slow down runoff water and let the sediment settle out behind the dam. Water can flow through the dam, but the rate of flow is reduced. They are usually only 1-3 feet high and are “keyed” into the banks on either side of the channel, i.e., the rocks on the ends of the dam are dug into the banks to reduce the chance of water cutting out around the ends of the dam. The dams are usually lowest in the middle so that when water overflows the dam in high runoff events and/or when the dam has filled with sediment, it will not cut out around the ends of the dam. Often additional rocks are placed below the dam to reduce the scouring of the channel when water flows over it. Dams are place in the channel at intervals which can be determined from guides developed for this purpose. Often the bottom of one dam is level with the top of the next dam downstream, although sometimes this interval can be increased. In some case, the rocks are wrapped in wire to prevent them from being detached by flooding. Another variant of loose rock dams is called “one rock dams”. These consist of several lines of rock laid across the channel, but the rocks are not piled up (Zeedyk and Jansens, 2006).

## What is the Purpose of Rock Dams?

As mentioned before, the purpose of installing loose rock dams in water channels is to slow the velocity of the water in those channels when runoff occurs. Reducing the rate of flow reduces the ability of the water to carry suspended sediments resulting in deposition of sediment behind the dam. The sediment also traps some water which may be retained in the sediment deposit, soak into the adjacent banks, or percolate into the material underlying the channel. The increased availability of water behind and near the dam may then promote the establishment and growth of vegetation. The vegetation also helps slow runoff and stabilize the channel and its banks. In some cases, the vegetation may continue the stabilization process upstream beyond the direct influence of the dams. So, the main purpose of loose rock dams is to stabilize drainages by trapping sediment and encouraging vegetation establishment. Some may suggest that the dams also increase ground water recharge, but no evidence of that has been produced, at least in the type of environment where this research was done.

## What Did the ARS Research Show?

### *Research Design*

The ARS research project was initiated in 2008 on two small watersheds at the Santa Rita Experimental Range east of Green Valley, Arizona. The watersheds had been instrumented and had data collected on runoff and sediment for many years prior to the rock dams. The watersheds occur on the alluvial bajada that slopes from the base of the Santa Rita Mountains to the Santa Cruz River. They are at an altitude of about 3,800 feet and receive about 16 inches of annual rainfall. Although the two watersheds were quite close to each other, they had different characteristics. According to the publications, Watershed #5 is located on the Combate soil series and Watershed #6 is on Comoro soil series. These soils were described as similar. (There is some confusion on this since in Nichols (2019) it says that the Combate soil is classed as an argid, which means it has a clay B horizon, and Comoro as a fluvent which means it lacks any B horizon – but the official description of the Combate soil does not show a clay B horizon.) Watershed #5 had a lower slope and less grass cover on the interfluves (area between drainages) than #6. It also had a different drainage pattern. The area of Watershed #6 was 3.1 ha (about 8 acres) and the area of Watershed #5 was 4 ha (about 10 acres). A total of 37 rock dams were placed, 10 in Watershed #6 and 27 in Watershed #5. The effects of the dams were evaluated by comparing runoff and sediment yield to the long-term records from each site, i.e., was the runoff different from expected based on long term records for a particular precipitation event?

### *Results*

The three publications listed in the photo study (and cited below) describe the research and results at several different stages, the most recent being in 2019, 11 years after the study began in 2008. The research on the Santa Rita showed that the effects of the dams were variable depending on the soils, landform, and vegetation of the site, i.e., the results were not the same on the two watersheds. Rock dams on both watersheds reduced runoff in small runoff events but had no effect on runoff in heavier storms. That is, they trapped some water but once the storage capacity was exceeded the runoff was not affected. The dams trapped sediment. Watershed #6, which had more grass cover on the interfluves, still have capacity to trap sediment after 10 years, i.e., the dams were not full of sediment. On Watershed #5, the dams were filled to capacity within about 3 years or less. On this watershed some dams were completely buried, i.e., they had no continuing effect except for the vegetation that may have established. Some of them diverted water to adjacent areas and initiated new drainages. Some dams caused some erosion below the dam due to scouring. Some of the dams failed and had to be rebuilt. The conclusion was that the effectiveness of the dams was variable depending on soil type and other factors. Other than the difference in grass on the interfluves, it is not entirely clear why the results were so different between the two watersheds, although more complete discussion is given in the publications. Vegetation did establish behind dams on both watersheds, as can be seen in the pictures in the online photo story cited previously, and this will probably continue to help stabilize these channels.

## Study Conclusions

Conclusions from this study are summarized here:

1. Loose rock dams did trap sediment and help vegetation to establish, thus increasing channel stability.
2. The effect was variable due to differences in vegetation, soils, and drainage characteristics.
3. The dams reduced runoff from small precipitation events but had no effect on large ones.
4. The dams were completely filled or buried in a short time on one watershed, but still had sediment trapping capacity on the other.
5. Because dams can fail, it is very important that they are properly designed and maintained.
6. Loose rock dams should be considered a “channel stabilization” treatment, not a “watershed restoration” treatment. They do not affect the vegetation cover on the interfluves where the runoff and some of the sediment originate.

## Other Observations on Rock Dams

Loose rock dams have been built in a number of locations in Arizona, and in some cases have apparently been very successful. One of those is on the Joe Austin Ranch located on the west side of the Chiricahua Mountains in Cochise County. Mr. Austin has implemented an aggressive program of trying to improve watershed condition by using loose rock dams, brush control, and other measures. The loose rock dams have apparently been very effective in prolonging stream flow in drainages on the ranch. *Figures 1-3* show photos of some of the dams taken in 1993. As can be seen, there are significant differences between these dams and the ones studied on the Santa Rita. The ranch is located at a higher elevation and higher precipitation zone than the Santa Rita (probably about 5,000 feet and about 18-20 inches of precipitation). The vegetation is oak woodland and juniper, primarily, rather than semidesert grassland. The stream channels are developed in bedrock as are the adjacent soils. The loose rock dams used are larger and composed of larger rocks. Due to the bedrock, the tendency to washout around the ends or to scour below the dams would be much reduced compared to those built on alluvial materials on the Santa Rita.

Another example in southern Arizona was a 10,800-acre watershed tributary to the San Pedro River where 5,200 loose rock dams were built around 1995 with an Arizona Water Protection Fund (AWPF) grant. This watershed was at an elevation of about 3,200 feet at the low end up to around 4,500 feet at the high end; average rainfall from about 12-16 inches. The AWPF conducted a survey of project in 2007 and reported that an estimated 75% of these dams had failed and had no effect on the watershed (Natural Channel Design, 2007). They attributed this to the "design not suitable for the conditions" but did not elaborate on what would be a suitable design.

There are some studies being carried out on watershed rehabilitation in several areas such as the Babacomari River, which were found online. Some of these are using various kinds of channel stabilization structures including rock dams, but no reports were found on their success. Zeedyk and Jansens (2006) describe erosion processes and measures to stabilize channels. They describe the use of "one rock dams" (those with layers of rock only one rock high) but does not mention loose rock dams.

There are some other observations I would add:

1. Loose rock dams are considered "low tech", i.e., they don't involve a lot of machinery or other technology to build. However, if not designed properly they will be ineffective and may cause more problems than they solve, i.e., there is some "high tech" input needed if they are going to be successful.

2. Loose rock dams involve a lot of hard manual labor, i.e., carrying and placing rocks. Access to the areas being treated may be limited to foot traffic. This means that rocks must be available on the surface that can be used. Not all areas meet this requirement.

3. Some dams will fail and thus maintenance is necessary to keep them effective.

4. The number of dams that may be required to treat a watershed may be large (e.g., 5,200 dams in a 10,800-acre watershed), therefore, this practice is likely to be restricted to relatively smaller areas with special importance. The amount of labor required to treat larger watersheds would cost a lot of money, assuming workers are paid, or require extraordinary dedication from volunteers. Some have suggested using prison labor.

5. As the ARS concluded, loose rock dams, or any other channel treatment, will not "restore" a watershed, although it may contribute to that restoration by helping to stabilize channels. Watershed restoration depends on establishing effective ground cover over the entire watershed, not just the channels. This cover will reduce or slow runoff thereby reducing the amount or rate of water flow in the channels, reducing sediment in the channels, and thus allowing vegetation to develop in those channels. In some cases, almost nothing that can feasibly be done will prevent bank cutting and head cutting in ephemeral channels due to altered flow regimes or lowered base levels due to arroyo cutting or other causes. *Figures 2 and 3* show eroded channels that are beginning to stabilize in the absence of any dams or other structures, partly as a result of brush control to help improve ground cover.

6. Although no studies were identified that address groundwater recharge, it appears highly unlikely that loose rock dams would contribute to groundwater recharge in many cases. For example, the moisture retained by the dams on the Santa Rita is almost certainly all used by the vegetation that establishes in or near the channel. The situation may be different on the Joe Austin Ranch or similar areas since the prolonged flow of water in the streams may contribute to recharge at the mountain front, where most of the recharge occurs.

## Conclusion

Loose rock check dams and other similar structures can be very effective in stabilizing eroding channels if properly located, designed, and maintained. They will not work everywhere. They also will not restore watershed function since they have little or no effect on the interfluves, i.e., the land that lies between the channels, which makes up the overwhelming majority of the area. The basic principle of watershed management is the "capture, storage, and safe release of water." This means the raindrop should be kept where it falls to the extent possible, and this cannot be achieved with channel structures, which only deal with runoff. Before committing to a program of loose rock dams or any other channel structures, careful consideration should be given to considering the costs and expected benefits of these programs compared to brush management, good grazing and forest management practices, reseeding, wildfire prevention, or other measures aimed at maximizing water retention and use on the entire watershed.

---

## References

Natural Channel Design. 2007. Final Report AWPR Grant Projects Evaluation. Phase II: Case Studies. Arizona Water Protection Fund. Phoenix.

Zeedyk, Bill and Jan-Willem Jansens. 2006. An introduction to erosion control. Quivera Coalition.

References from photo study:

Nichols, Mary H., Viktor O. Polyakov, Mark A. Nearing and Mariano Hernandez. 2016. Semiarid watershed response to low-tech porous rock check dams. Technical Article. Soil Science Vol 00 Number 00: pages 1-8.

Nichols, M.H. and V.O. Polyakov. 2019. The impacts of porous rock check dams on a semiarid alluvial fan. Science of the Total Environment 664: 576-582.

Polyakov, V.O., M.H. Nichols, M.P. McClaran, and M.A. Nearing. 2014. Effect of check dams on runoff, sediment yield, and retention on small semi arid watersheds. Journal of Soil and Water Conservation 69 (5):414-421.

Figure 1. Loose rock dam on Joe Austin ranch 1993. Note size of rocks, size of dam and bedrock on both sides of channel. Larry Humphrey and Joe Austin in photo.

Figure 2. Loose rock dam on Joe Austin ranch 1993. Note debris on upside of dam indicating that it ran over.

Figure 3 Brush control (mostly juniper) on Joe Austin ranch 1993.

Figure 4 Lehmann lovegrass starting to stabilize eroded channel after creosotebush control near San Simon. No channel treatment was done.

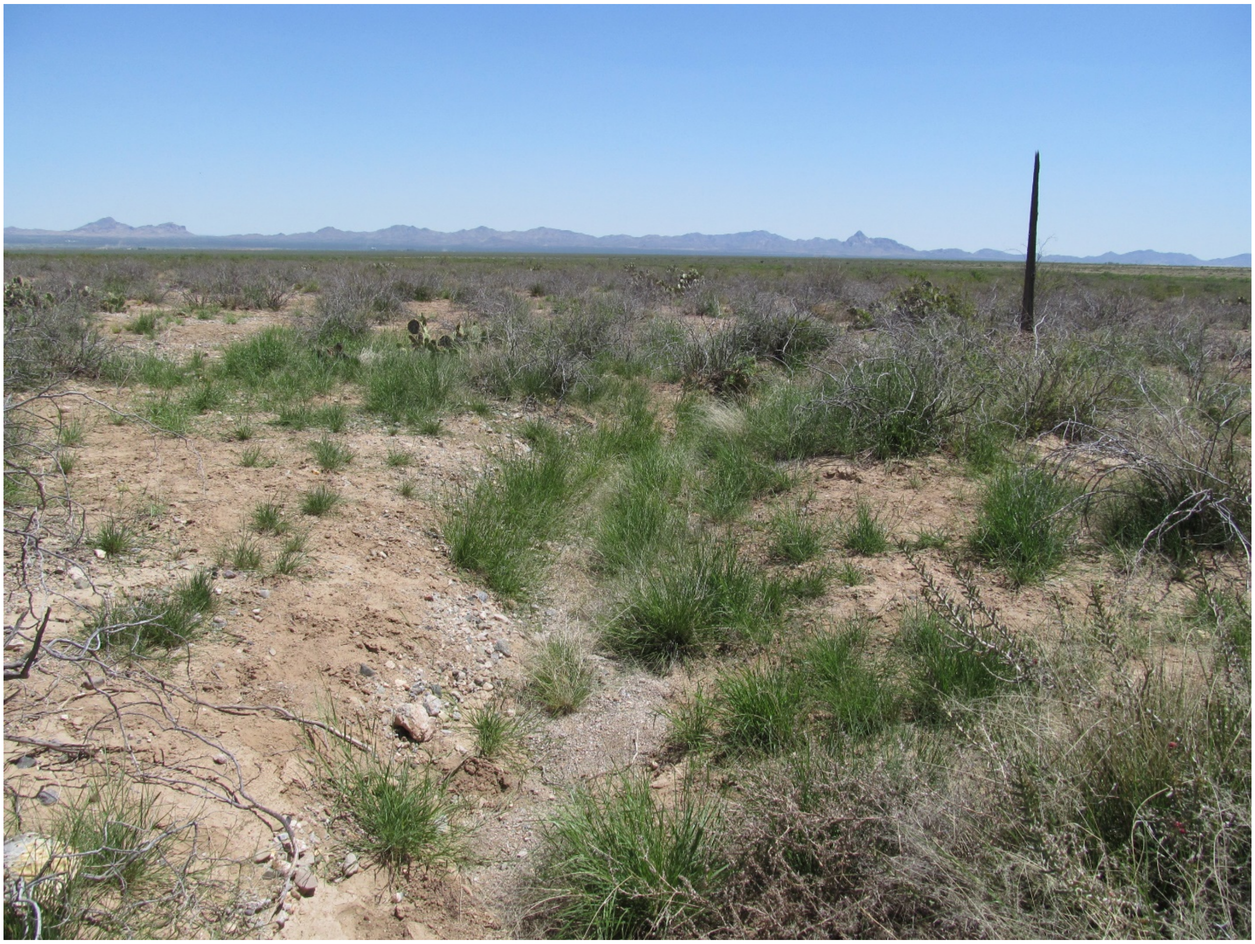

Figure 5 Lehmann lovegrass growing in eroded channel after control of mesquite and other shrubs – near Tombstone. No channel treatment was done.