WATER HARVESTING FEATURES USED IN MINE RECLAMATION, NAVAJO MINE[1]

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Abstract: The arid Southwest is associated with a sparse vegetal cover and highly erosive landscapes. The sparse vegetation is largely the result of low annual precipitation and the erosion is largely the result of high intensity short duration storms which, at Navajo Mine, most frequently occur in late summer. Storms of this type have high runoff and result in little soil moisture retention.

Through special landscape shaping, personnel at Navajo Mine have used several means of harvesting water that are supporting greater plant densities than what is normal to an arid climate and controlling erosion in what were previously highly erosive areas. These features consist of both above and below ground structures that reduce runoff, retain moisture for longer times during drought periods and support vegetation that is suited for controlling erosion. This paper discusses the construction and effectiveness of water harvesting features at Navajo Mine.

Additional Key Words: Water harvest; Reclamation; Soil Moisture.

Introduction

Navajo Mine is located on the Navajo Reservation in the San Juan Basin of Northwest New Mexico. Precipitation at the mine is extremely variable but averages seven inches annually. The majority of the precipitation comes as high intensity short duration storms during the late summer months. Reclamation success has been difficult to establish at the mine because of the low and unpredictable precipitation. In spite of these limitations, Navajo Mine has had some success with establishing both vegetal cover and a diverse ecosystem through special landscape shaping and construction of water harvesting features. These features were designed to improve the long-term diversity and suitability of the plant communities for the post mine land use, which is livestock grazing. In addition, the features provide a mechanism for controlling long term erosion.

The area selected for constructing the field designs described in this paper are in the North portion of the mine on pre-law (Pre-SMCRA) lands known as the Watson and Bitsui Pits. Pre-law lands were selected, since Federal Law does not allow for the construction of water harvesting features. A total of 800 acres were reclaimed in these pre-law areas during 1992 and 1993. Various water harvesting features were incorporated into the regular reclamation program with the attempt to create approximately one feature per every eight acres. During the spoil regrading process, the land was divided into various topographic aspects, that would support the different types of water harvesting features. After regrading was complete and the features created, the 800 acres were topdressed, seeded with a mixture of native shrubs, forbs and grasses, and irrigated for one year to achieve establishment. There were approximately 6,000 transplants and 1,000 pole cuttings installed at the water harvesting features.

Discussion

Water harvesting can be enhanced by utilizing several landshaping techniques. At Navajo Mine these were divided into two categories; subsurface and surface features. There were three subsurface features utilized; 1) rockpiles and cliff structures, 2) surface drainage traps and 3) deep topdressing reservoirs. Surface features consisted of two features; ponds and depressions.

The primary objective of all water harvesting features was to retain water, minimize runoff and thus control erosion. These features, when judiciously placed on the reclaimed landscape can be effective in reducing peak flows from large storms and minimizing or eliminating flows from small storms.

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A result of water harvesting is an increase in localized moisture on the reclaimed area which improves the vegetal density and diversity. Additionally, landform stability is improved, erosion potential is reduced, and soil moisture losses resulting from evaporation and runoff are decreased.

Subsurface Water Harvesting Features

The subsurface water harvesting features that were used at Navajo Mine each apply the same principal for storing water below the surface. A hole or reservoir is cut into the final regraded surface of what are generally clay spoil materials. In some cases, compaction may be used to insure that the lining of the feature is sealed. The reservoirs are backfilled with coarse sands or river cobble to create a highly permeable subsurface reservoir. The areas are covered with varying depths of topdressing to accommodate the needs of the feature. Each of the three types of subsurface water harvesting features used at Navajo Mine has its own design specification and purpose. A description of each follows:

Rockpiles and Cliff Structures

Rockpiles and cliff structures harvest and store water in a similar fashion. The reservoir is excavated to the desired dimensions, partially filled with highly permeable materials (cobble and sand) and then the feature is constructed. Precipitation can enter the subsurface reservoir directly from the driplines or from surface runoff. These two features are dissimilar in that they are built on different landscapes and may provide different functions.

Rockpiles (Figure 1) are generally constructed on level to nearly level terrain and generally have small drainage areas that provide the surface runoff to the subsurface reservoir. The reservoir is typically 20 ft. in diameter and 4 ft. deep but varies. The surface rockpile is of variable shape, size, height and orientation depending on the landscape and function (e.g. nesting, roosting, wind block, etc). The rockpile is constructed with large rocks (3 ft. in diameter or larger) which are stacked 7 to 10' high. Depending upon their profile, they can trap large amounts of drifted snow which is released into the subsurface reservoir. The stored moisture then becomes available during drought periods.

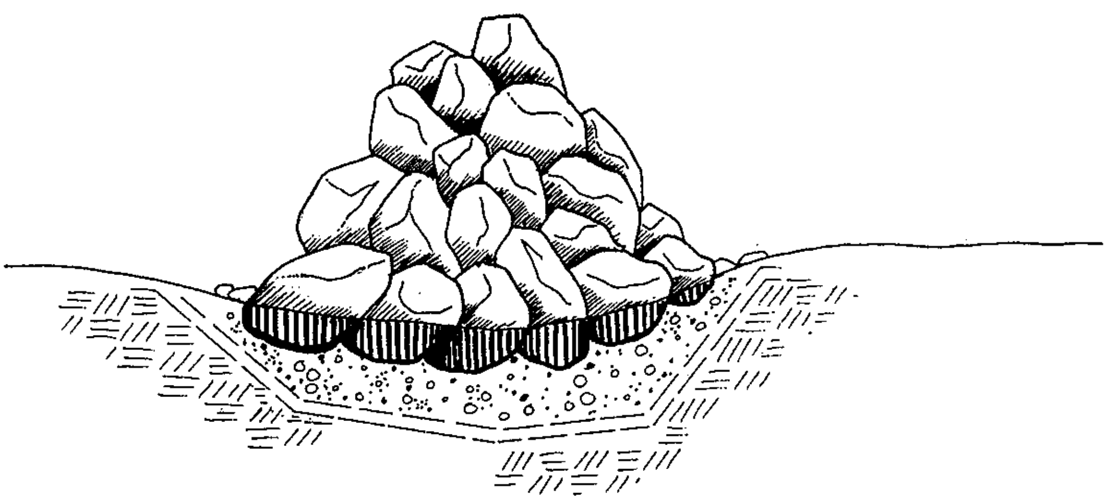

Figure 1. Rockpile feature, structure and design.

Cliff structures (Figure 2) are generally located at the crest of long, steep slopes and constructed to resemble cliffs existing before pre-mining. An additional purpose of using cliff structures is to minimize the erosion potential by reducing both the length and grade of the slope below the cliff structure. The cliff structures are constructed by cutting an almost vertical face along the ridge. The length is largely dictated by the shape of the ridge and the amount of available rock. The bottom of the cut is sloped back into the hill at an approximate 4:1 slope and back-filled to a level grade with the coarse materials. Large rocks (flat sandstone are preferred) are stacked into the cut against the back-wall to the crest of the ridge. The design requires that the watershed (if created) above the cliff structure does not erode the back-wall behind the rocks. These structures generally provide additional water to vegetation below the cliff.

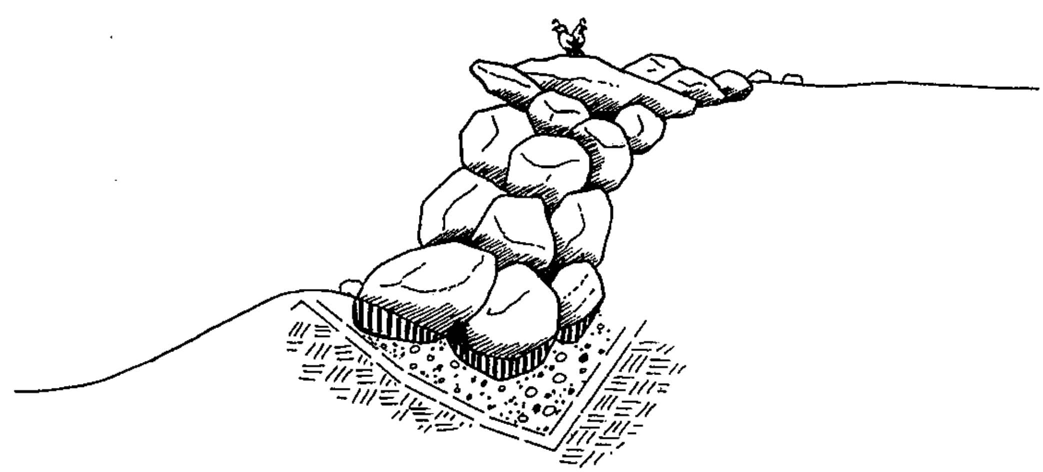

Figure 2. Cliff feature, structure and design.

Surface Drainage Traps

Drainage traps (Figures 3a and 3b) are located in the bottom of drainage channels and are designed on the same basic principles of harvesting water below rockpiles and cliff structures. The primary purpose of the drainage trap is to control erosion. The additional water in the channel will support riparian type plant materials, which are well suited for controlling erosion. Drainage traps are constructed by excavating trenches in the bottom of drainages and backfilling them with coarse materials. The size and depth will vary depending on the amount of erosion control required. Generally at Navajo Mine, most of the drainage traps have been constructed by trenching a ditch approximately 4 feet deep x 4 feet wide, across the entire channel and perpendicular to the flow. Cottonwood and willow poles are then planted in or nearby the trenches to utilize the moisture and provide a dense vegetative barrier that will slow runoff, reduce erosion an provide diversity in the area. The spacing and placement of traps along the channel is dependant upon channel length, slope and the need to control erosion. Other drainage trap practices have been carried out at the mine for protecting the outside of channel curves and channel intersections. The same construction principals apply for these practices.

Topdressing Reservoirs

Topdressing reservoirs may be constructed by a number of methods. Typically the features are not readily noticeable but the principles of water harvesting remain the same as other surface designs. The objective is to create a diverse vegetative community and to minimize surface runoff. The two most effective methods of construction are spoil pitting and contour topdressing placement.

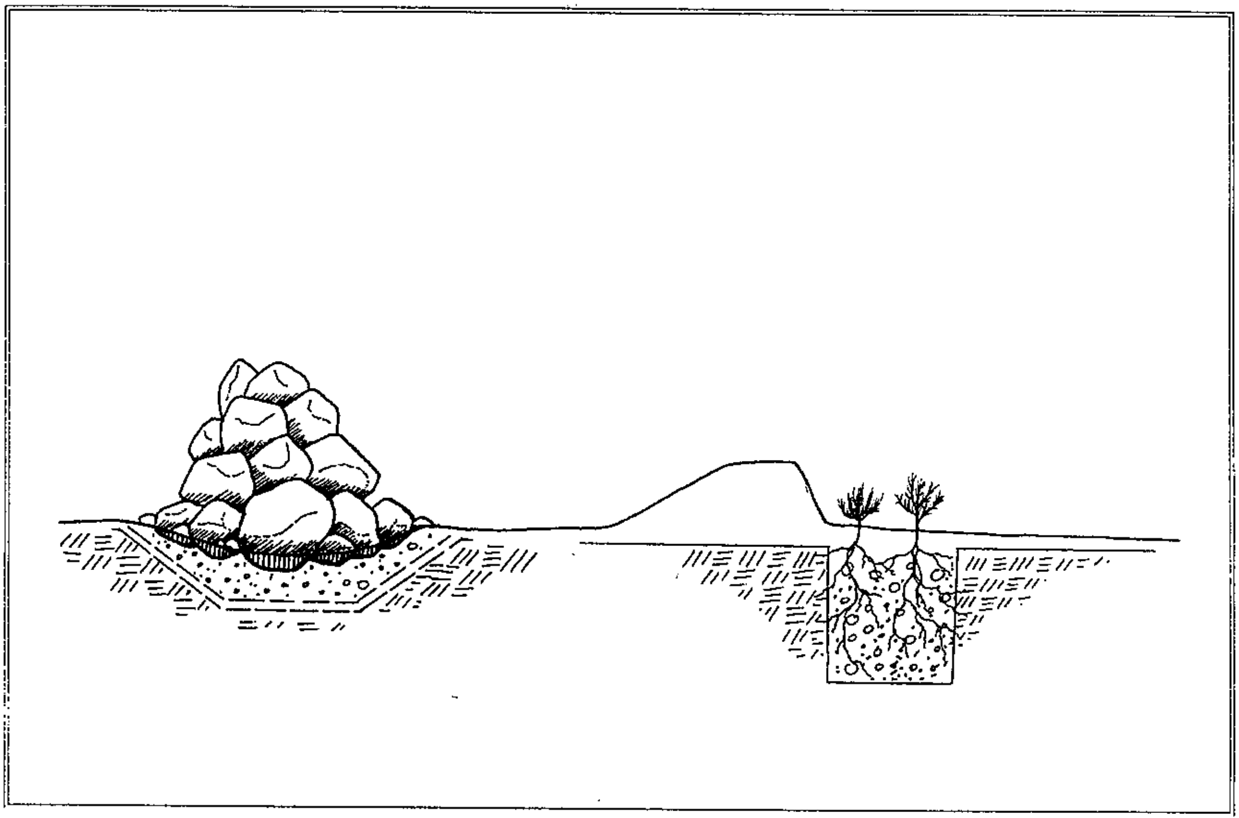

Figure 3a. Surface drainage rock-fill diversion dam feature, side view.

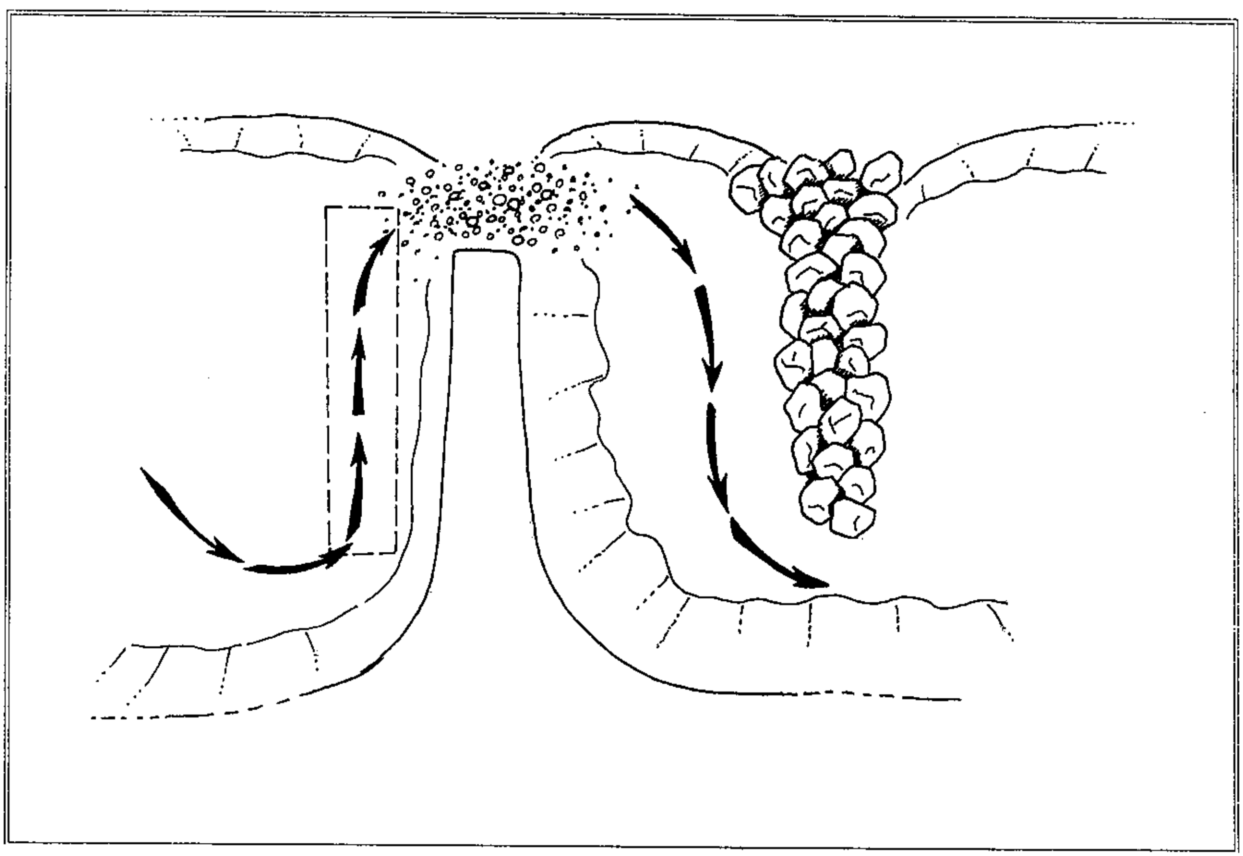

Figure 3b. Surface drainage rock-fill diversion dam feature, top view.

Spoil pitting involves a regular gouging of the regraded spoil surface to create an "egg-carton" effect in the regraded landscape. The depth of gouging varies, generally less than two feet, but should be designed to effectively eliminate runoff on gently sloping to level terrain. The treated area is topsoiled to a final grade that is smooth. Highly permeable topsoil is required for the spoil pits to be most effective.

Contour topdressing placement can also have a similar effect as the spoil pits. In this design topdressing is differentially placed as deep (1-2 feet) and shallow (1/2 ft.) strips across the slope contour. The hummocky terrain is designed to accumulate runoff between the strips. The topdressing should be highly permeable to maximize the effectiveness of this feature.

Surface Water Harvesting Features

Ponds may take several forms and functions. However, almost all are "designed" structures with specific characteristics to control flows, reduce sediment loss and provide seasonal (perhaps year long) water sources for supporting the post-mine land use of livestock grazing. As a general rule, ponds at Navajo Mine will only be established on watersheds that generate three-acre feet of runoff or less from a 100-year, 6-hour storm. The pond will be designed to contain at least twice this volume. The purpose of oversizing the retention ponds is to allow long term sediment storage and to minimize discharges. Eventually, the ponds are expected to fill with sediment. The sediment is typically topdressing material which at Navajo Mine is sand to loamy sand. A sand filled pond functions with the same principal as a drainage trap. The water will infiltrate down to the clay spoils and be retained in the sandy materials away from surface evaporation for long term plant use. The sediment filled pond, in time becomes a subsurface pond that supports a very dense plant community. The dense plant community acts as an erosion control tool and sediment filter that extends across the entire pond area.

Ponds may be constructed as incised features, with dams or a combination of ponds and dams (Figure 4). Incised ponds are preferred as spinwalls. Outflowing channels are the same elevation and long-term erosion is generally not a problem. Most ponds are located in small upland watersheds where channel grades are low. Ponds are generally built to minimize the surface area to depth tare. This minimizes evaporation and retains water in the pond for potential livestock use. Inlets may, as needed, be armored to prevent erosion and head cutting. Dams are generally avoided as their longetivity is poor and failures create high sediment yield.

These features are also used to create diversity by planting willow *(Salix sp.)*, cottonwood *(poplar)* poles and hydrophytic vegetation (i.e. cattails).

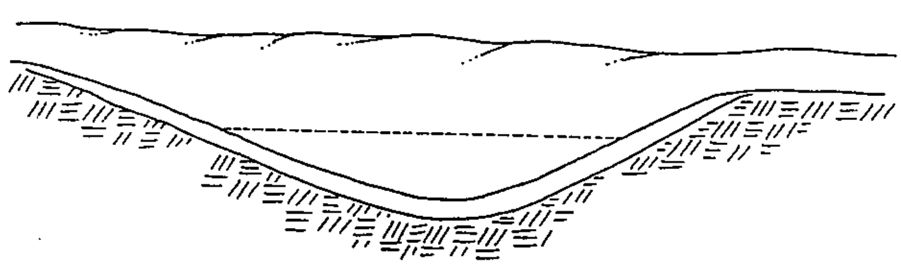

Figure 4. An incised pond feature.

Depressions serve the same functions as ponds. These features are not designed and are generally very small, and more numerous than ponds. They are primarily located in uplands where spoil peaks have been reduced into spoil valleys leaving a basin that is intentionally non-draining. At the lowest point in these basins, a depression is constructed to capture runoff and reduce the surface area of the water. Inlets are installed and armored (if necessary) to eliminate head cutting back up the slope. The bottom of depressions may be compacted in the same manner as ponds to eliminate rapid infiltration.

Vegetation and Wildlife Responses

Since 1992, water harvesting features at Navajo Mine have shown positive results. The areas around each type of feature frequently support high densities of plant materials. The subsurface harvesting features support mostly tree and shrub species while the surface features support a mixture of grasses, shrubs and trees. In the upland around many of the surface harvesting features, the cottonwood and black willow pole plantings have effectively survived drought periods during 1993 and 1994. Some of the trees have grown over six feet since 1992. During the two drought periods, since 1992 much of the vegetation around the various harvesting features remained green and continued to grow while the other vegetation away from the features was dormant.

Many transplant species suited for wetter climates and higher elevations have responding well, especially those located on the north side of rockpiles and cliff structures. The species include the New Mexico Olive (Forestierra neomexicana), chockcherry (Prunas virginia) and Woods Rose (Rosa woodsii). Even a few one-seed junipers (Junipeus monosperma) and Piñons (Pinus edulis) have survived on thee north faces of rockpiles.

In the channels where the drainage traps have been installed, vegetation response is still uncertain. While the shrub species appear to be establishing well, the pole plantings have not been as successful. A factor that might explain the poor success is the substantial length of time between planting and the time they first received water. Also the leaves for many poles had already emerged from the buds before planting. In most drainage traps where perforated pipes (<5 ft deep) were installed to determine water depth, it was found that water was present throughout the year.

Erosion Responses

One of the objectives of the water harvesting structures was to assist in the control of erosion and sediment loss. The drainage traps have been effective in both sediment control and sediment filtering, especially in the areas where the vegetation is dense. The density of vegetation around the drainage traps appears to be increasing each year and is expected to continue. The surface water structures have on several occasions received flows, resulting in no discharges.

Some secondary benefits have also been observed from the water harvesting features. Water foul have begun utilizing the surface ponds and mammals, and rodents frequent the ponds for watering. Insect populations have also increased around the ponds. The rockpiles and cliff structures are being used as dens by coyotes, and foxes, hiding places by rodents and rabbits, and perching sites for raptors.

Conclusions

Over 100 water harvesting features (six types) were established on 800 acres of rehabilitation during 1992 and 1993. The vegetation establishment and growth around each type of water harvesting features have responded well. Plant species, normally adapted to higher elevations and wetter climates have been successful at the mine. Tree plantings have been successful on a mine site that previously did not support trees. Some key milestones for judging success has been the plant survival and growth response noted through two drought periods, each lasting over three months during the summers of 1993 and 1994. In addition, there have been several intense rain storms to gauge the success of the erosion control aspects. The water harvesting features had definite positive results. The secondary benefits have also proven successful with the increased sightings of birds, mammals, rodents and insects that use the newly formed habitats. The various water harvesting features are a significant contribution to a stable and diverse ecosystem at Navajo Mine.

Navajo Mine has had the opportunity to demonstrate some very promising reclamation practices by using the different types of water harvesting features because the 800 acres were on pre-law land. Navajo Mine was able to demonstrate many rehabilitation techniques that under permanent program regulations could have never been accomplished. It is hoped that this successful program will lead to improved methods that will be used on permanent program reclaimed lands.