Figure 1. View of parking lot, left above, at Sacaton. Note loose compaction of slope.

Figure 2. A view of the backside of water tank hill slope, right above. Note extreme length of slope-drip lines spaced approximately 15 feet apart.

Drip Irrigation for Revegetating Steep Slopes in an Arid Environment

*by Stuart A. Bengson**

Revegetation of disturbed sites in any arid environment is difficult due to the adversities of climate, alkaline-saline soils and the lack of organics on the disturbed sites. In addition, revegetation problems are increased by the slopes often encountered in disturbed areas. The first problem is a vital need to revegetate steep slopes for erosion control. The second problem is that the usually arid conditions are magnified by the excessive droughty condition created by the slope itself. Water either runs off the slope or drains rapidly through the soil before the plants have an opportunity to utilize it.

Techniques to revegetate steep arid slopes have not been developed. Tech-

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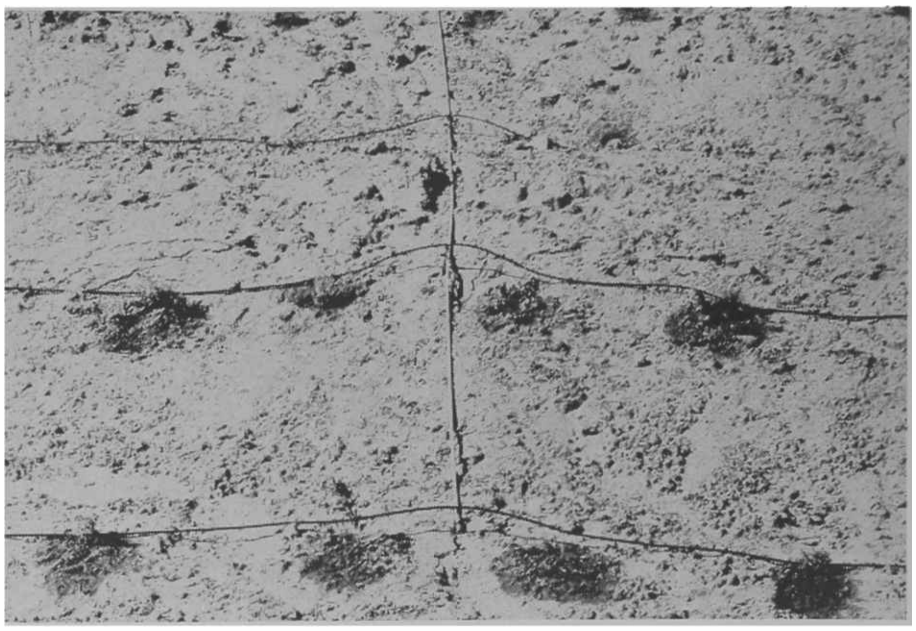


Figure 3. A view of the frontside of water tank hill slope. Note linear arrangement of plants. Open pit mine visible in background.

Figure 4. View of the slope drop illustrating linear displacement of plants. Note extent of west surface area. The emitters are on a random spacing of 10 feet along the lines.

niques used to revegetate gentler contours in an arid environment are not applicable to steep slopes. Pitting and gouging to create moisture conserving basins is usually negated by the inability to get equipment on the slope. Placement of collars or aprons around individual plants to conserve moisture is also hampered by inaccessibility. Supplemental watering, even though widely used to ensure successful revegetation in the arid environment, is often inapplicable due to the erodibility of the slopes.

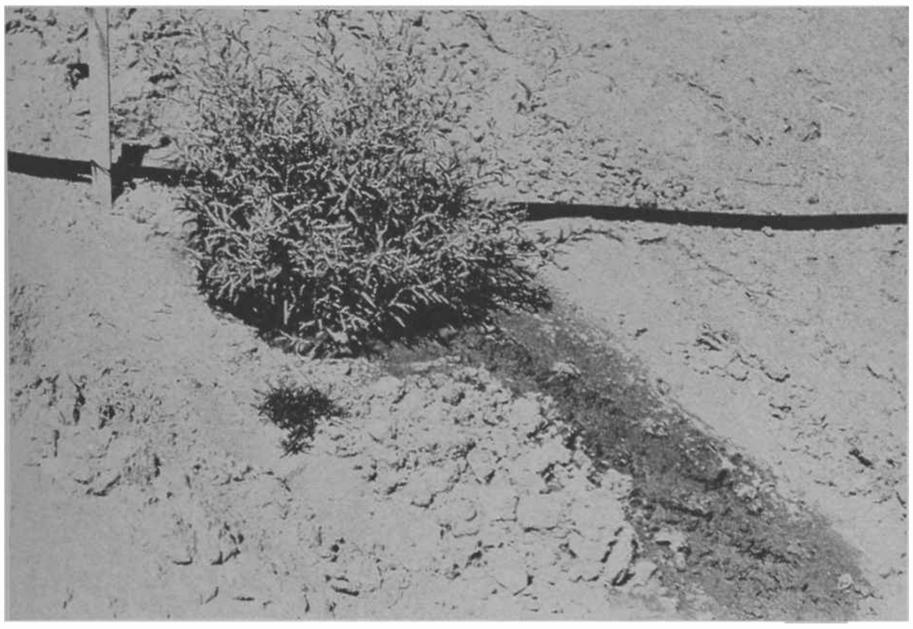
ASARCO recently dedicated its Sacaton Mine Unit near Casa Grande, Arizona. Revegetation of all disturbed areas has been included in the total mining program. The newly constructed water tank hill and parking lot were the first areas selected for revegetation. The basis for this selection being that these were the first areas deactivated from heavy traffic and the prominence of their visual impact. These areas were constructed of alluvial overburden material removed from the open pit mine. This material is fine textured, alkaline (pH 7.9 - 8.4), and lies on a 2:1 natural angle of repose. These constructed slopes were not compacted, adding to the drainage problem. Due to the steepness and length of these slopes (slope length varies from 15′ - 150′) they are very erosive. Revegetation of these slopes was also hindered by the high reflectance of the soil and the total lack of organics.

Added to these harsh man-made conditions are the adversities — of the local environment. Sacaton Unit lies at the lower end of what is described as the "Phoenix Desert Shrub Environmental Zone."[1] This is a low elevation area (1000′ - 2000′ MSL), with low annual rainfall (6″ - 8″ per year) and high mean average temperatures (high of 90° F. low of 50° F.). The natural vegetation consists mostly of creosote bush (*Larrea tridentata*), palo verde (*Cercidium sp.*), desert salt bush (*Atriplex polycarpa*), mesquite (*Prosopis sp.*), triangle-leaf bursage (*Franseria deltoidea*) and annual grasses and forbs. Very few perennial grasses exist naturally in the area.

Several factors were considered in the design of the revegetation program for the Sacaton Unit. The single most deciding factor was the low annual precipitation. As a rule, in vegetative erosion control, perennial grasses are used. These grasses shield the surface, build up the soil, and their fiberous root systems form a sod. In an arid environment germination and initial establishment of perennial grasses is generally accomplished with the use of sprinkler irrigation. Due to the sparse rainfall at Sacaton, this method of vegetative stabilization was judged unsuited. Species of perennial grass seed commercially available would be stressed for survival on the limited rainfall. Even if perennial grasses were established, they probably could not perpetuate a perennial grass community after supplemental watering was removed (the main purpose of irrigation is only to establish vegetation that can survive on the natural rainfall, and once this vegetation is established, the irrigation can be removed). Also Sacaton's water system is not capable of supporting a sprinkler irrigation system at this time.

For these reasons native shrub and tree species adapted to this arid environment were selected for revegetating the Sacaton Unit. Although their root system is not as fiberous as grasses, shrub roots go deeper and they do an acceptable job of soil stabilization. Shrubs and trees have the one disadvantage of not having the density of a grass cover and leave open areas between plants which are

[1] *GUIDE TO IMPROVEMENT OF ARIZONA RANGELAND,* Univ. of Arizona *Cooperative Extension Service Bulletin A-58, Oct., 1973.*



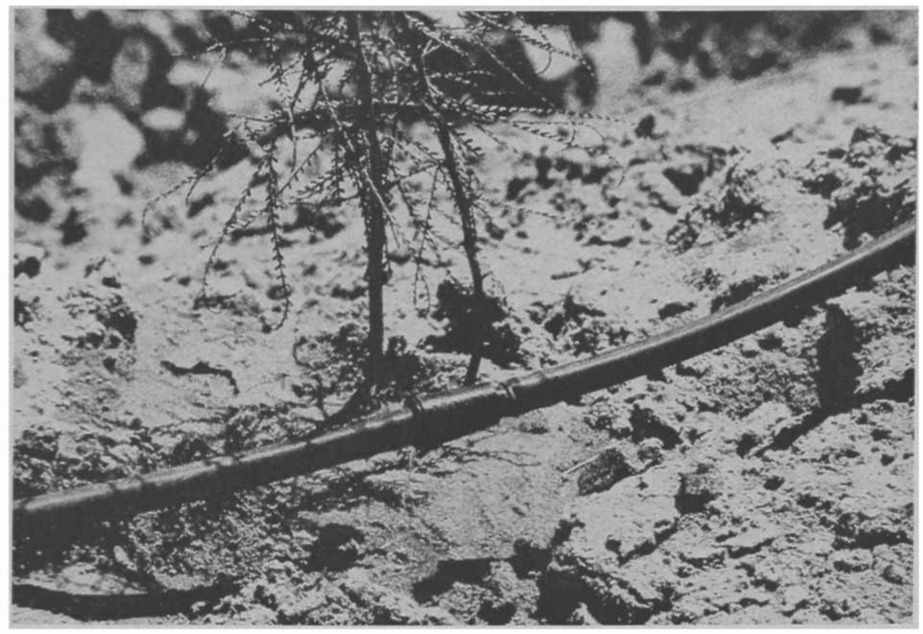


Figure 5. Close-up view of *Atriplex canescens* on drip system. Note size of plant. Planted as gallon size stock three weeks previously.

Figure 6. Close up view of drip emitter. Note growth and vigor of *Parkinsonia aculeata.*

subject to possible erosion. In time these open areas should fill in with indigenous annual weeds and plants as seed is blown in from the surrounding desert and trapped by the shrubs. To facilitate the establishment of these trees and shrubs at Sacaton, a drip irrigation system was selected.

Drip, or trickle irrigation, is a system that has been especially adapted for use in arid environments. Originally designed for use in hydroponic agriculture it has become increasingly popular for farming in arid regions. Agricultural application of drip irrigation was first developed in Israel in the early 1960's and has now expanded to Australia and the southwestern United States. Use of this system in arid land revegetation stems from its use in California along highway berms.[2]

The primary advantage of drip irrigation is the conservation of water. Of more importance to revegetating steep slopes, drip irrigation has the capability of applying sufficient water to a plant at a slow enough rate to alleviate the hazard of run off and subsequent erosion. Also of importance of revegetation of harsh sites is the ability of drip irrigation to leach excess salts and other phytotoxins from the root zone. Other advantages include: savings in water systems development costs due to lower flow volume and pressure requirements necessitating smaller pipe and pumps; ability to fully control fertilizer applications (when injected into the system); portability of the system; and it helps plants grow faster and develop deeper roots (due to the deeper wetting zone). Also the spacial arrangement and plant density can be altered to more closely approximate the natural surroundings.

Disadvantages of drip irrigation can involve costs. A basic system with filter and fertilizer injector can cost anywhere from \$300 - \$3,000 per acre depending on desired plant density. Closely spacing plants increases costs tremendously. Other disadvantages involve the possible accumulation of salts at the edge of the wetting zone (especially in poorly drained soils), the drip system only wets a small surface area and is relatively ineffective for producing solid vegetative cover, and wildlife have a tendency to chew on the plastic components of the system. Maintenance is required to keep the drippers unplugged (some commercially available systems are more trouble free than others) and contraction and expansion caused by temperature fluctuations have a tendency to separate the lines at the joints. Also spacial arrangement of plants can trend towards straight lines.

At the Sacaton Unit gallon sized nursery stock was used to revegetate the slopes utilizing the drip irrigation system. Approximately 2,300 plants were planted on a 10′ x 15′ spacing pattern on the water tank hill and parking lot slopes. Species used include: palo verdes (*Cercidium floridum* and *Parkinsonia aculeata*), mesquite (*Prosopis sp.*), bursage (*Franseria deltoidea*), hopseed (*Dodonea viscosa*), brittle bush (*Encelia farinosa*), salt bushes (*Atriplex canescens* and *semibaccata*) and desert broom (*Baccharis sarothroides*). These species were selected for their adaptability to the local environment, fast growth and form, color, and harmony with the surrounding desert flora. The trees and taller shrub species were planted along the top and bottom edges of the slope to disrupt the smooth, flat visual impact of the edge, while the lower growing shrubs were used to provide cover and stabilization to the interior slopes.

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[2] *CURRENT ACTIVITIES IN MINE TAILING STABILIZATION & BEAUTIFICATION Dr. E. D. DeRemer & D. A. Bach, May, 1974.*