Paved Drainage Basins as a Source of Water for Livestock or Game[1]

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There are roughly 728 million acres of rangeland in the continental United States. Although most of this area is available for grazing, a large portion does not have adequate water for livestock. One of the main reasons for this inadequate development is the high cost per animal unit. The practicability of developing water is usually determined by total cost and the number of animals that can be watered at each place. Obviously more money can be spent for water development on ranges with high grazing capacity than on units with low capacity.

Stock water supplies may be obtained from many sources and by many means. There are, however, only a few major sources. These are primarily (a) running water such as streams or springs, (b) wells, and (c) stock ponds (known as tanks and charcos in the Southwest). Where streams or springs are available, the provision of adequate water may be no problem or at least a minor one. When wells must be relied upon, cost becomes an immediate and often a limiting factor. Stock ponds may not be feasible in low rainfall areas, in sandy locations with little or no runoff, or where the soil is too porous to hold water.

Other Rainfall Collection Structures

When the collection of runoff water in some sort of storage basin or cistern must be relied on, it may be essential to reduce percolation and evaporation losses to a minimum. This has been done in some instances by paving or otherwise surfacing the drainage area and constructing some type of watertight cistern or reservoir. Although this general method of collecting water has been used for no one knows how long, surprisingly little application is made of it today, except in some rural areas to provide water for domestic purposes. Only occasionally has it been resorted to as a source of water for livestock.

The first development of this type to come to the attention of the senior author was located near Ruidoso in southern New Mexico and was first seen in 1937. The structure consisted of a low roof from which the water drained into a concrete cistern. The cistern was largely underground and was covered to exclude dirt, small animals, etc. A cement stock-watering trough nearby was equipped with a float valve and filled by gravity flow from the cistern. The stock water thus provided made it possible to graze an area that previously could be utilized only during the summer rainy season.

Some years later the senior author examined a second structure west of Albuquerque, New Mexico that utilized this same principle. In this instance, however, the drainage area had been surfaced with soil-cement. Due, apparently, to improper construction, the structure had frost heaved rather badly and was rapidly becoming useless. The water was collected in an open pond subjected unavoidably to large evaporation and percolation losses.

Other structures employing this principle have been constructed in Arizona on the Sitgreaves and Coconino National Forests[2]. The Sitgreaves Forest development was built in 1934-35, primarily to water sheep. Water collects from a galvanized-iron roof that drains into a 70,000 gallon steel cistern underneath the roof. Although there are other similar watering places on the forest, the one described above is the oldest. It has been in continuous use since 1935 as a source of water for both sheep and cattle. Total cost of construction was $4,180.00. It is located in SE¼SW¼ sec. 20, T. 12 N., R. 17 E., on the Heber Ranger District of the Sitgreaves National Forest.

The structure on the Coconino National Forest was built in 1953-54. The construction here was quite different from that of the Sitgreaves Forest development. The ground was cleared of all vegetation, smoothed and firmed before being covered with ¼ inch asphalt sheets. Water is collected in a 12,000 gallon dirt storage tank and a 5,000 gallon circular cistern.

Quoting Mr. McDermaid's letter —"This tank met all expectations during 1953. The 12,000 gallon tank filled and ran over in 1953. The original tank has now been supplemented by a second tank of about the same size."

This structure, which cost approximately $2,300 is located on House Mountain, in section 29, T. 16 N., R. 5 E. It is used as a source of water for cattle.

The Arizona Game and Fish Commission has utilized this same principle in the construction of a number of game-watering developments. These have been designed in some instances primarily as a source of water for quail or other birds, in others for use by deer and javelinas as well as birds.

Location of Area

The drainage-collection area

[1] *Arizona Agricultural Experiment Station Technical Paper No. 387.*

[2] *Personal communications dated 6/6/55 from H. V. Allen, Jr., U. S. Forest Service, Holbrook; and 3/18/55 from F. E. McDermaid, U. S. Forest Service, Flagstaff.*

noted in southern New Mexico raised the question whether structures of this sort might not logically be used much more widely as a source of stock water. No cost or collection-efficiency data were known, however, that would indicate the feasibility of this type of construction. In order to provide some of these data a small drainage area was paved and a cistern was constructed in 1951 on the University of Arizona Page-Trowbridge Experimental Ranch, about 30 miles north of Tucson. The area lies at an elevation of about 3,500 feet and has a mean-annual rainfall of approximately 14 inches. About half of this falls during the 6-month period from April through September; half from October through March. Although the site originally supported a stand of grasses with few or no shrubs or trees, today it is essentially a mesquite savanna. Intermixed with the mesquite is a wide variety of other woody species, notably cacti and burroweed (*Haplopappus tenuisectus*). The native grasses are largely gramas (*Bouteloua spp.*), cane beardgrass (*Andropogon barbinodis*), three-awns (*Aristida spp.*)and cottontop (*Trichachne californica*). A recent reseeding program introduced two exotic lovegrasses (*Eragrostis lehmanniana* and *E. chloromelas*) which are rapidly covering areas not already occupied by grasses.

Structure Description

A triangular area 100 feet on each side (4,330 square feet), was cleared of vegetation and scraped with a road grader to a uniform 3 per cent grade free of irregularities (Fig. 1). An asphalt-water emulsion was mixed with river-run sand on the scraped area. This was then spread to a uniform depth and compressed with a hand-pushed roller to a final thickness of about 2 inches. The surface was finally top-dressed by spraying with asphalt. Later, an 8-inch border was thrown up to keep outside water and debris from washing onto the pavement.

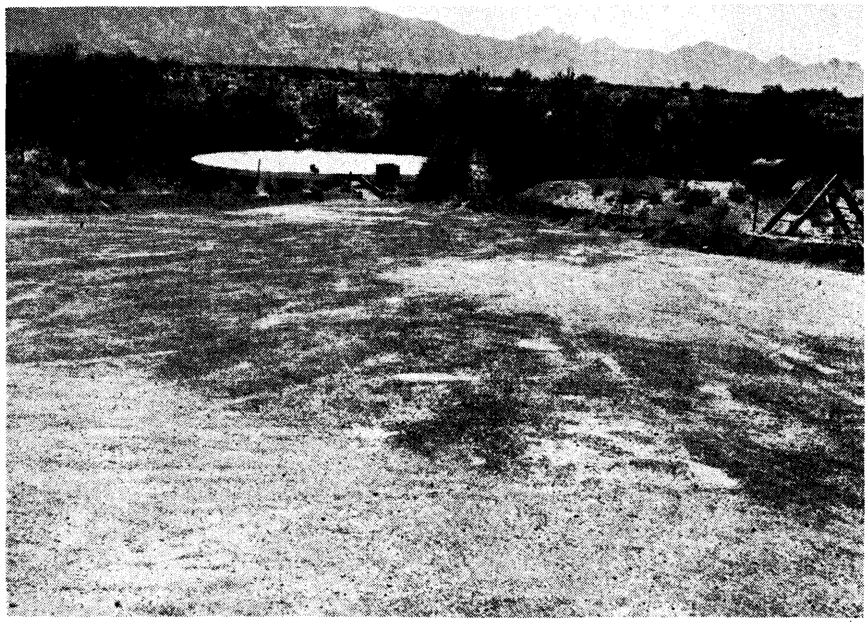

FIGURE 1. Asphalt-paved runoff area showing appearance of surface 3 years after construction and cistern in background.

The cistern, which was located immediately below the runoff area, was of poured reinforced concrete with a capacity of 29,700 gallons. A sheet-aluminum roof sloping to the center, was added to keep evaporation at a minimum and to prevent entry of small animals.

Discussion

This pavement differs from the usual asphalt roadway or parking lot surface in that the usual pavement is designed to resist distortion from loads. This is done by keeping the binder, a liquid, at a minimum and using a well graded aggregate in which the granules will not move readily once they are cemented in place. The runoff area, on the other hand, does not need any compression strength as it has almost nothing to support. As a consequence, liquid or solid asphalt would be ideal except that at the temperature to which it would be heated by the summer sun, it would have a tendency to flow or creep. Further, the use of straight asphalt would be expensive, unless it was spread rather thin. A thin application, however, would shorten the life of the asphalt so much as to make its practicability questionable.

The best results are obtained by using enough asphalt to leave a slight excess in the aggregate voids after the suspending water or viscosity-cutting solvent has evaporated. This will be approximately 30 per cent more asphalt than is usually used for paving. Rolling or compacting need be sufficient only to remove any entrapped air.

The surface should be sealed as soon as the water or solvent has completely evaporated. A light seal of gravel chips or sand should finally be applied primarily to protect the asphalt surface against sunlight. This gravel will cause some detention of water if not rolled into the surface.

Paved runoff-collecting structures offer certain advantages over wells as a source of stock water. The cost can be calculated in advance for the size of structure desired and there is no possibility of ending up with a "dry hole." Secondly, although the probability of receiving any specific amount of precipitation is unpredictable, there is a good correlation between precipitation and forage production. As a consequence, in those years when little water accumulates in the cistern there is also little forage produced. Obviously

Table 1. Cost of construction of paved drainage basin.

Runoff Area	
Excavation, 18c per cu. yd.	$ 41.00
Asphalt application (485 yd. @ 72c)	349.20
Fencing (4 strand barbed wire)	16.82
Posts (38 @ 80c)	30.40
Posts (4 corner)	50.00
Fencing labor	40.00
Cistern and Trough	1,500.00
Total	$2,027.42

the reverse is also true; years of maximum forage production will tend to be years of maximum stock-water storage.

Slope is a basic consideration in selecting sites for paved-drainage-area stock-water developments. The drainage area can be most easily constructed where the slope is gentle, preferably where it is more than 2 and less than 5 percent. It is desirable to have a steeper drop-off immediately below the drainage area as this permits construction of the collecting cistern nearby. A slight additional drop below the cistern permits gravity flow to a watering trough equipped with a float cut-off valve.

Rather small amounts of rain falling on an impermeable surface may accumulate rapidly as rather considerable volumes (Table 2).

In the calculations shown here no allowance has been made for losses due to evaporation and adhesion to the collecting surface. The percentage of moisture that is lost in these ways increases with a decrease in the amount that falls during a given shower. When the total for a given period is comprised of increments from a large number of light showers, therefore, these losses may be considerable.

An attempt was made in this study to determine the relation between amount of precipitation and amount of storage. Due, however, to faulty operation of the rain gauge and to destruction of records by rodents, it was not possible to obtain any reliable correlations. The cistern did fill rather rapidly after completion and, except when drained to construct the roof, or when used for irrigation purposes, has remained essentially full. As the experimental ranch has for the most part been closed to domestic livestock, game (deer and javelinas) have constituted almost the only grazing animals using the water.

The size of the storage cistern or reservoir should be determined by the carrying capacity of the range unit for which water will be provided, the length of the grazing season and the character of the precipitation pattern. Assume, for example, that a stock tank of this sort will provide water for stock ranging out for 1-1½ miles in all directions. This would include an area of approximately 7 square miles. If this range will carry 10 head per section, water will have to be provided for 70 head. Taking 10 gallons per day per head as the average year-around daily water consumption by range cattle, the total daily consumption will be 700 gallons, or 21,000 gallons per month.

Table 3 shows calculated cistern storage capacities required for various stocking rates and various-length grazing periods.

The size of the cistern to be used by a specified number of animals should be determined by season of use and precipitation pattern. A range grazed 4, 6, or 8 months of the year, therefore, will require water for these periods rather than for a full 12 months. Most pinyon-juniper ranges, for example, are best used as spring-fall units grazed for about 2 months in the spring and 2 months in the fall.

Table 2. Theoretical storage from a 1,000-square-foot runoff area.

Precipitation *Inches*	Storage *Gallons*
.1	62
.2	125
.3	187
.4	249
.5	312
.6	374
.7	436
.8	499
.9	561
1.0	623
2.0	1,247
3.0	1,870
4.0	2,494
5.0	3,117
6.0	3,740
7.0	4,364
8.0	4,987
9.0	5,611
10.0	6,234

Table 3. Cistern storage capacities required for various stocking rates and various-length grazing periods.

Stocking Rate	Water (gallons) Required for Grazing Period*						
Head/sec./mo.	*1 mo.*	*2 mo.*	*4 mo.*	*6 mo.*	*8 mo.*	*10 mo.*	*12 mo.*
2	600	1,200	2,400	3,600	4,800	6,000	7,200
4	1,200	2,400	4,800	7,200	9,600	12,000	14,400
6	1,800	3,600	7,200	10,800	14,400	18,000	21,600
8	2,400	4,800	9,600	14,400	19,200	24,000	28,800
10	3,000	6,000	12,000	18,000	24,000	30,000	36,000
12	3,600	7,200	14,400	21,600	28,800	36,000	43,200
14	4,200	8,400	16,800	25,200	33,600	42,000	50,400
16	4,800	9,600	19,200	28,800	38,400	48,000	57,600
18	5,400	10,800	21,600	32,400	43,200	54,000	64,800
20	6,000	12,000	24,000	36,000	48,000	60,000	72,000
22	6,600	13,200	26,400	39,600	52,800	66,000	79,200
24	7,200	14,400	28,800	43,200	57,600	72,000	86,400
26	7,800	15,600	31,200	46,800	62,400	78,000	93,600
28	8,400	16,800	33,600	50,400	67,200	84,000	100,800
30	9,000	18,000	36,000	54,000	72,000	90,000	108,000

* 10 gallons per head per day.

As it can be assumed that any water used will be replenished during the summer and again during the winter, only a 2 month supply need be furnished. Thus, for the 10-head-per-section range postulated above, a 42,000 gallon cistern would have to be built.

No allowance for evaporation is made in any of these calculations on the assumption that any storage reservoir will be roofed. The water may be stored, however, in open dirt tanks and in such instances allowance would have to be made for evaporation and percolation losses.

The asphalt-paved runoff area has weathered very satisfactorily during the 5 years it has been in operation. Although the surface has a few minor cracks, it appears to be essentially as waterproof as when first laid down. During this period it has received no maintenance except the application of 2,4-D to a few weeds that grew through the asphalt in one area.

Summary

A triangular area containing 4,300 square feet was paved with asphalt in a 14-inch rainfall zone in southern Arizona. Rainwater from this area has been stored in an adjacent cistern. As a source of water for livestock this type of construction appears to be feasible where other cheaper or more dependable sources of water are not available.

ACKNOWLEDGMENT

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