# STOCK-WATER HARVESTING WITH WAX ON THE ARIZONA STRIP

by

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## INTRODUCTION

Water harvesting has been an important way to supplement water supplies on the Arizona Strip of northwestern Arizona for years. It is the only feasible method for supplying water to livestock in many areas of the Strip, because perennial springs and streams are rare, and groundwater is very deep being strongly influenced by the Grand Canyon which forms the east and south borders of the area, or consists of isolated perched water aquifers. Installation of an adequate grid of watering spots through pipelines and hauling is extremely expensive because of the great distances between existing reliable supplies. Water harvesting is also expensive because usually common construction materials like concrete, sheet metal, and butyl rubber are used as catchment aprons. However, recent research at the U. S. Water Conservation Laboratory (Fink et al., 1973) has shown that catchment aprons treated with inexpensive paraffin wax yielded 90% runoff without any measurable decrease in efficiency (Fink, 1976) after 4 years. In September 1974, two catchment aprons were treated with paraffin wax on the Arizona Strip at costs substantially below those of most previous catchments. This paper is a report of the materials used, the cost of the total water harvesting system, and the results of the first year of operation.

## DESCRIPTION OF WATER HARVESTING SITES

### HURRICANE VALLEY OR SLOPE CATCHMENT

This 1-acre catchment is about 45 miles south of St. George, Utah, on the west side of Hurricane Wash. Average annual precipitation in the area is about 12 inches, approximately half of which falls in winter as rain and snow showers and the other half in summer as thundershowers (Sellers and Hill, 1974). The catchment is constructed on a clay loam soil at a slope of 5 to 8%. The apron was graded, treated with a soil sterilant, and wet compacted before the wax was applied. Unfortunately, the soil surface was inadvertently disturbed immediately before treatment to remove some weeds, and thus was not in ideal condition when treated.

### SNAP POINT OR GARRETT CATCHMENT

This 3/4-acre catchment is about 100 miles south of St. George, Utah. The 12- to 16-inch annual precipitation has seasonal distribution similar to that at Hurricane Wash. The catchment is constructed on a sandy clay loam soil at a slope of 5 to 8%.

## INSTALLATION PROCEDURES

The apron treatment, storage tank, evaporation-suppressing cover, connecting pipes, and fencing are the same at both sites. The treatment consisted of applying 128° F average melting point (AMP) paraffin wax to the soil surface at a rate of 1.7 $lb/yd^2$. The wax (supplied in 2,002-pound cartons, each containing 182 11-pound blocks) was loaded by hand into a 2,000-gallon capacity asphalt distributor truck and then melted to 270° F with the truck's burners. Melting time was considerably shortened by using the truck's pumping system to circulate the molten wax from the tank bottom to the unmelted blocks at the top. Once the entire 800- to 1,000-gallon load was melted (4 hours), it was sprayed on the apron in only 30 minutes through the truck's spreader bar.

Water collected is stored in 80,000-gallon tanks with steel sides and concrete bottoms. The sides (made of 12-gauge, 6-foot-wide, 10-foot-high, multiplate corrugated steel) were bolted together and the joints sealed at the site. After assembly, the tank was placed on 4-inch concrete blocks and a 6-inch reinforced concrete floor was poured into the tank and extended about 6 inches outside, using ready-mix concrete supplied from St. George. Water is conveyed from the catchment apron to the tank by 100 feet of 15-inch-diameter corrugated steel pipe. Evaporation is controlled by a floating cover of 1/4-inch foamed rubber that is slightly smaller in diameter than the steel tank. The floating cover is protected from blowing or floating off the tank by two #9 galvanized wires stretched across the top at right angles, and by a series of holes in the tank wall, near the top, for overflow. Water is supplied to a water trough through a 1 1/4-inch plastic pipe, using a float valve in an underground float box for water level control.

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The entire water harvesting system, except the trough, is surrounded by an 8-foot-high net wire fence to prevent damage by livestock and wildlife.

## WATER COLLECTED DURING FIRST YEAR

Estimates of the amounts of water collected at the two water harvesting sites are based on precipitation data from several monitoring stations near the catchments. Runoff efficiency was assumed to be 90%, based on runoff from similarly treated catchments at the U. S. Water Conservation Laboratory's experimental Granite Reef site east of Mesa, Arizona, and on observations of runoff during rainfall at the sites.

Rainfall at the Hurricane Valley site totaled 10.8 inches between September 1974 and September 1975. With 90% runoff efficiency, nearly 265,000 gallons of water should have been collected. An estimate of the disposition of the collected water is as follows:

| | |
|---|---|
| Evaporation loss (Cooley, 1970) | 5,000 gal |
| Used by cows (70 head for 270 days at 10 gal/day [Schulz and Austin, 1976]) | 190,000 gal |
| Remainder = spill during year (some spill observed) | 5,000 gal |
| Storage in tank at end of year (observed) | 65,000 gal |
| Total water collected | 265,000 gal |

Rainfall at the smaller Snap Point site was 10.5 inches during the year. This amounts to nearly 200,000 gallons of runoff, assuming 90% runoff efficiency. Because this range section has another water source, we assumed that usage by cows was equally divided between the two sources. Estimated disposition is:

| | |
|---|---|
| Evaporation loss (Cooley, 1970) | 5,000 gal |
| Used by cows 1/2 (150 head for 200 days at 10 gal/day [Schulz and Austin, 1976]) | 150,000 gal |
| In storage at the end of the year | 35,000 gal |
| Remainder = spill during year (some spill observed) | 10,000 gal |
| Total water collected | 200,000 gal |

Evaporation rates at both sites were estimated to be 72 inches per year (Cooley, 1970), which would have amounted to nearly 50,000 gallons of water. Cooley and Myers (1973) found that floating foam rubber covers reduced evaporation losses by about 90%, which would save 45,000 gallons of water at each site.

## ECONOMICS OF WATER HARVESTING SYSTEMS

Cost of the various components of the two systems and the labor and equipment required for installation (1975 prices) are presented in Table 1. Included are (1) prices of individual items; (2) subtotals for apron, tank, installation, and other items; (3) cost per unit area of apron; (4) cost per 1,000 gallons of storage; and (5) total system cost.

A first estimate of the cost of the collected water can be made by dividing the total cost of the completed water harvesting systems by the total amount of water collected during the year. This calculation is presented in the upper portion of Table 2 for the two sites. Based on this 1-year method, any water collected in the future would be free, unless additional costs for maintenance or re-treatment are incurred. Even if all of the costs are charged to this first year of operation, the costs of the collected water are competitive with the $2,000 to $5,000 per mile costs for piping or the $15 to $37 per 1,000 gallon costs reported for hauling water (Pearson et al., 1969; Peden, 1971; Roberts, 1971), especially when these figures are adjusted for the rough terrain and remoteness of this area and for the increased costs since these figures were compiled.

A more realistic approach would be to amortize the cost of the system over at least 10 years. Maintenance and re-treatment costs must be added to initial costs in this case. Estimated costs of the collected water, assuming the same amount of water collected each year and two wax re-treatments on the aprons, are presented in the lower portion of Table 2.

Regardless of the method used to determine the cost of the water collected, this method of supplying water is competitive with other methods such as hauling or piping. Of even greater economic benefit is the water saved by the floating foamed rubber cover. As shown in Table 1, this cover costs $350. Amortized over a 10-year period, this amounts to $350 x 0.149 = $52.15/yr. The cost of the 45,000 gallons saved each year would therefore be (52.15 ÷ 45,000) x 1,000 = $1.16/1,000 gallons, or about one-fifth the cost for collecting the water originally.

## LIMITATIONS OF WAX TREATMENTS

The results of the first year of operation of these two wax catchments are very encouraging, especially when compared with other systems where aprons cost 3 to 10 times more (Frasier, 1975). However, because some paraffin-treated aprons have failed, this treatment cannot be universally recommended. The wax seems to work best on sandy soil, although other soil factors such as the kind and percent of clay and the presence of gypsum influence the effectiveness.

Comprehensive laboratory tests are underway (Fink, 1976) to determine which soils can be effectively treated with wax, and under what climatic conditions. Different types of waxes and combinations of wax and other materials are being tested on a variety of soil types. The laboratory tests are designed to evaluate two major types of treatment failure: (1) lack (or loss) of water repellency, and (2) lack (or loss) of structural stability. Hopefully, even cheaper, more effective water-repellent materials will be found that can be used under a variety of soil and climatic conditions.

## SUMMARY AND CONCLUSIONS

Two water-harvesting systems constructed on the Arizona Strip of northwestern Arizona for which common paraffin wax was used to waterproof the apron have proved very successful during the first year of operation. Both provided water at a cost competitive with that for hauling or piping water into the sites, even if the entire cost of the system was charged to the first year of operation. If costs were amortized over a 10-year period, the cost of the water collected would be between $5.74 and $7.26 per 1,000 gallons or less than one-third that for hauling and piping. Water saved by reducing evaporation losses was an even greater bargain, costing only $1.16 per 1,000 gallons.

Wax treatments are most effective on sandy soils and in warmer climates. Laboratory and field studies are being conducted to delineate the applicability of a variety of different waxes and wax mixtures on a wide range of soil types, and under various climatic conditions.

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Table 1. Cost of water harvesting systems.

| | | Hurricane Valley | Snap Point |
|---|---|---|---|
| Apron: | Paraffin wax | 1250 | 925 |
| | Truck and driver - 5 hrs at $38/hr | 190 | 190 |
| | Soil sterilant | 100 | 100 |
| | | $1540 | $1215 |
| | (Cost per square yard of apron) | ($.32/yd$^2$) | ($.33/yd$^2$) |
| Tank: | 80,000-gal, steel sides | 2900 | 2900 |
| | Concrete bottom (26 yd$^3$) | 670 | 770 |
| | Reinforcing wire, seam sealer, etc. | 265 | 265 |
| | Floating 1/4-inch foamed butyl cover | 350 | 350 |
| | | $4185 | $4285 |
| | (Cost per 1,000 gallons of storage) | ($52/1000 gal) | ($54/1000 gal) |
| Other: | 15-inch culvert with flared end | 1000 | 1000 |
| | 250 ft of 1 1/4-inch pipe, 10-ft trough | 175 | 175 |
| | 8-ft net fencing and barbed wire - 52 rods | 450 | 450 |
| | | $1625 | $1625 |
| Installation: | BLM crews and equipment | $1800 | $1800 |
| | Total cost of system | $9150 | $8925 |

Table 2. Cost of collected water.

| | Hurricane Valley | Snap Point |
|---|---|---|
| Total cost absorbed in first year | | |
| Cost of system | $9150 | $8925 |
| Water collected | 265,000 gal | 200,000 gal |
| Cost per 1,000 gallons | $35/1000 gal | $45/1000 gal |
| Cost amortized over 10 years | | |
| Maintenance cost (valves, floats, etc.) | $ 120 | $ 120 |
| Re-treatment cost (2 treatments at 1 pound/square yard | 1450 | 1100 |
| | $1570 | $1220 |
| Average cost per year | $157/year | $122/year |
| Average cost per year of initial investment at 8% interest (Capital recovery factor = 0.149) (Linsley and Franzini, 1964) | $9150 x 0.149 = $1363/yr | $8925 x 0.149 = $1330/yr |
| Total cost per year for 10 years | $1363 + $157 = $1520/yr | $1330 + $122 = $1452/yr |
| Cost of water collected | $1520/265,000 = $5.74/1000 gal | $1452/200,000 = $7.26/1000 gal |