

PROCEEDINGS

The Range Beef Cow

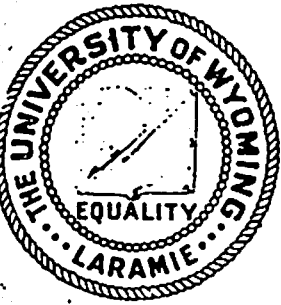
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DEVELOPMENT OF WATER FOR GRAZING MANAGEMENT

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INTRODUCTION

The grazing animal, with minimum assistance from man, is one of the most efficient converters of plant biomass to protein on land which is generally unsuited for more extensive types of agriculture; however, this protein food source may be reduced in the future. Many acres of traditional grazing land are being lost to urban or small ranchette developments or are being placed under intensive sprinkler irrigation for grain production (Pendleton 1979). At the same time, there is an increased tendency to reduce or restrict grazing activities on public lands to stop the deterioration of soil, plant, and water resources. To maintain the present level of meat production from the grazing animal, the forage resource of the range must be efficiently utilized. In arid and semiarid regions, a major factor that limits the optimum utilization of the available forage resource is the lack of uniform dispersion of animal drinking water.

The relationship of drinking water availability, forage consumption, and animal performance is only partially understood. It includes various complicating factors such as the type of feed, air temperature and humidity, and water temperature (Winchester and Morris 1956; Sykes 1955; Rittenhouse and Sneva 1973). A study in central Oregon showed there were no lasting effects on the body weight of cattle when water was restricted 20 to 25% for periods of 90 to 130 days (Sneva et al. 1973; Sneva et al. 1977). Butcher et al. (1959) found that weight gains were reduced when water was restricted by 25% for 25 days, but the animals fully recovered to the level of the control animals within 5 days following the end of the water restriction period. Animals on a 50% water restriction for 25 days did not reach the weights of the control animals after 25 days of free access to water. During the water restricted periods, the daily forage intake by the cattle was correspondingly reduced. If continued long enough, a water-induced reduction of forage intake can affect the animals' performance (Squires 1978).

Studies have shown that cattle will graze at considerable distances (up to 3.5 miles) from drinking water supplies (Herbel et al. 1967). There are indications that, when livestock are forced to travel long distances to water, such as in arid areas, the drinking patterns may change to a watering every-other-day frequency (Sneva et al. 1973). Even if the livestock will trail relatively long distances from water, this is not the best practice for optimum animal performance. When water supplies are widely spaced, the animals can spend appreciable time traveling from the grazing area to the water and back, which reduces the time available for grazing and digesting the feed (Squires 1978).

Factors other than available forage affect the distance animals will move away from water. Martin and Ward (1970) showed that topography significantly affects animal movement. When livestock limit their travel distance, for whatever reason, overgrazing will occur around the water source. Forage growing outside the normal grazing range is economically worthless for grazing cattle, even though it may consist of excellent stands of desirable plants.

FORAGE UTILIZATION AND WATER AVAILABILITY

Forage utilization that provides for continuing optimum plant production will vary depending upon factors such as climatic conditions, soil type, and plant species (Bement 1969; Van Poolien and Lacey 1979). A study on native pastures in eastern Nebraska showed that a shift in animal grazing patterns, induced by the development of additional drinking water sources, changed the utilization of various plant species and, when coupled with favorable climatic conditions, significantly improved the vegetation composition of the pasture (Jensen and Schumacher 1969).

As a general rule, many ranchers try to achieve an average of 50% utilization (Renner and Love 1955). In the Northern Great Plains, the suggested utilization rate is 40 to 75%, depending upon the topography and dominant grass species (Stoddart and Smith 1955). In the arid Southwest, the recommended utilization rate is 35 to 50%, depending upon the grass species and with adjustments to permit consideration of rainfall occurrences (Reynolds and Martin 1968).

In some areas, the uniformity of forage utilization can be improved by cross-fencing pastures and placing animal salt away from the drinking water sources (Martin and Ward 1973). There is a limit to the distances from water that animals can be moved by these techniques without adversely affecting animal performance. The development of additional drinking water supplies is an effective means of distributing the livestock throughout the pasture.

Topography is a significant factor in determining the location and spacing of animal drinking water supplies. One recommendation is that permanent water sources should not be more than 4 to 5 miles apart on flat land, 3 miles on rolling land, and 1 to 2 miles on rough terrain (Reynolds and Martin 1968). Sneva (1979) suggested that the distance between forage supplies and drinking water should be 1/4 to 3/4 mile apart for the greatest uniformity of grass utilization. Figure 1 shows the results of forage utilization studies with increasing distances from water on a 2,435-acre pasture in New Mexico with a single water source in one corner (Valentine 1947). The data shows heavy utilization (>60%) for the first 0.2 miles, then a general decline within the optimum utilization range (40 to 50%) for a distance of 0.2 to 0.8 miles. There was a significant decline in utilization (<20%) at 0.8 and 1.4 miles, then an increase to a maximum 40% utilization at 1.4 to 2.0 miles. The increased utilization at distances greater than 1.4 miles could be a result of topography features or salting practices. Results of a similar study in Montana showed that the forage utilization of summer forage was less than 30% at distances greater than 0.5 miles from the central water, even with remote placement of salt and some

temporary water sources on the outlying areas of the pastures (Holscher and Woolfolk 1953).

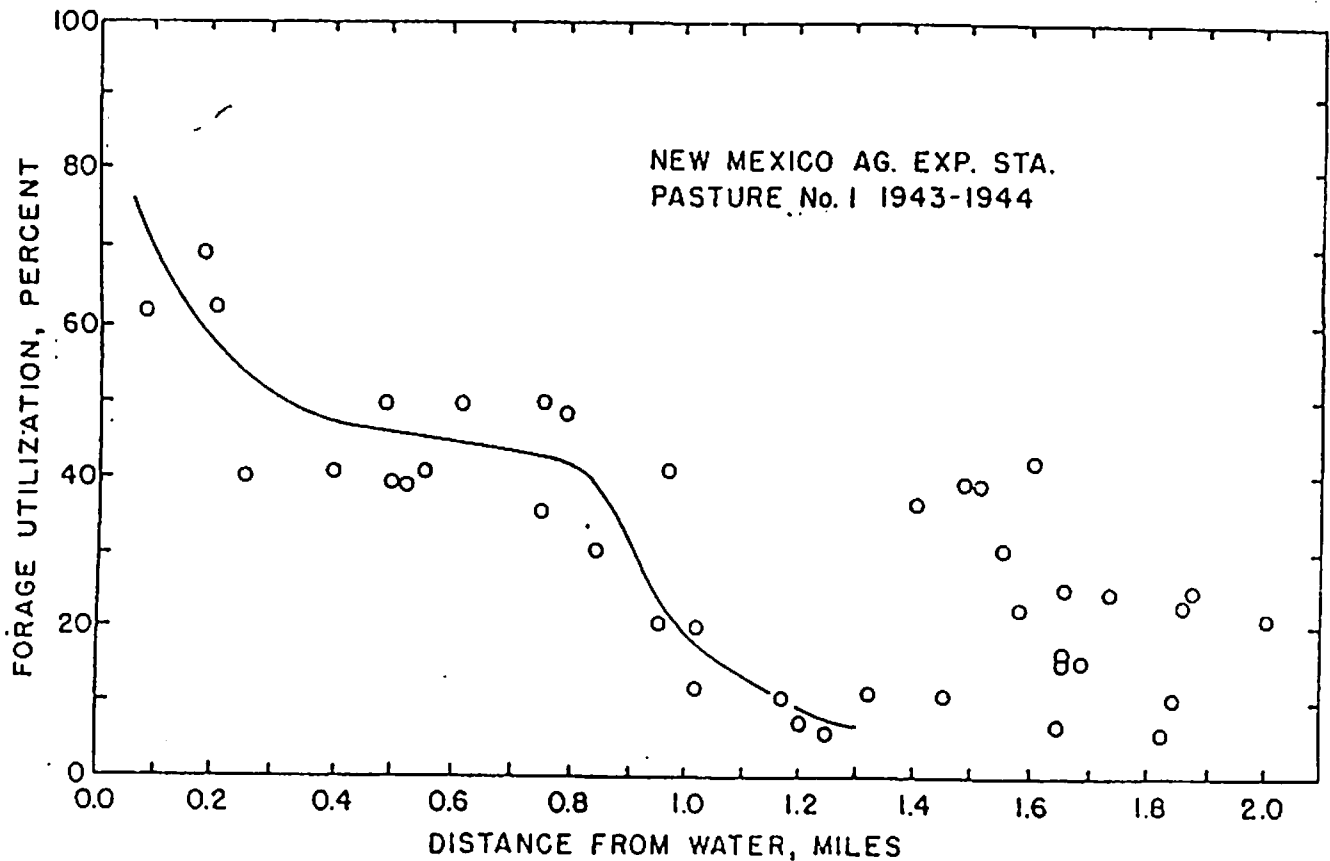


Figure 1. Forage utilization with increasing distance from water (Valentine 1947).

Figure 2 shows the grazing pattern that would result from the relation between utilization and distance, depicted by the line on figure 1, if a single water source were located at the center of a square pasture 2 miles on a side (2560 acres) without topographic features, cross fencing, or salting schemes to restrict or enhance animal movement. The straight line animal travel distance would be 1 mile or less for most of the pasture. Figure 3 shows the grazing pattern from the same pasture with the same utilization-distance relation which might occur if there were four water sources located in the center of each quadrant. With this water distribution, most of the area is less than 1/2 mile from water.

Table 1 shows the areas for the various degrees of forage utilization for the two animal watering systems shown in figures 2 and 3. With one centrally located water source, about 20 acres around the water, representing less than 1% of the total area, would be severely overgrazed (> 70% utilization). An additional 160 acres (6% of the total area) would be heavily utilized (50 to 70%). The desired 40 to 50% utilization would occur on 1110 acres (43% of the total area). The remaining 1270 acres (50% of the area) would be at less than the 40% utilization level. The same pasture, with four water sources, would have 80 acres (3% of total area) with greater than

70% utilization, 640 acres (25% of total area) with heavy utilization (50 to 70%), and 1840 acres (72% of total area) with the desired 40 to 50% utilization. Most likely, with the additional water sources, the areas of heavy forage utilization would be smaller than indicated, because there would be fewer animals at each water source, and over the years, through range condition improvement, would allow for increased production.

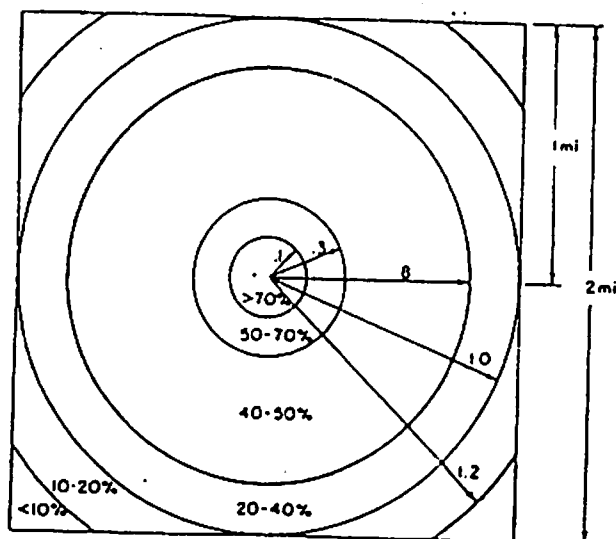


Figure 2. Forage Utilization pattern in a pasture with single centrally located water source.

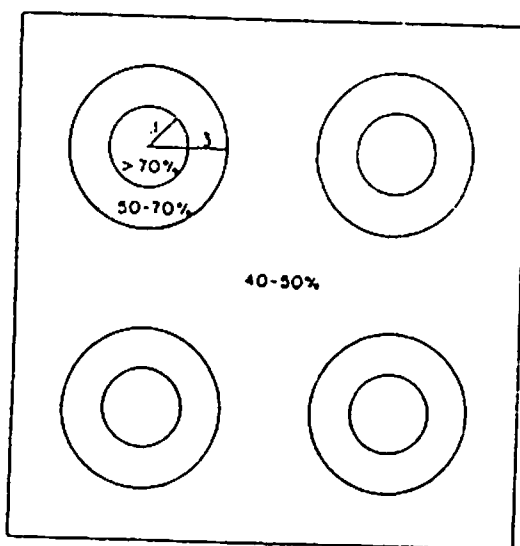


Figure 3. Forage utilization pattern in a pasture with four equally-spaced water sources.

Table 1.--Comparison of relative areas of utilization from 2560-acre pastures with one water source and four water sources.

Utilization	Radius of use	1-water source		4-water source	
		Area of use		Area of use	
(%)	(mile)	(acres)	(%) ¹	(acres)	(%) ¹
>70	0.1	20	1	80	3
50 - 70	0.3	160	6	640	25
40 - 50	0.8	1110	43	1840	72
20 - 40	1.0	720	28		
10 - 20	1.2	410	16		
<10		140	5		
		2560	99	2560	100

¹Percentage of total pasture area.

Assuming that the percent of forage utilization can be used as an index of grazing capacity (Stoddard and Smith 1955), 50% of the total area in the pasture with the single central water supply is potentially capable of carrying more livestock. By increasing the number of water sources from one to four can potentially change the utilization of the outlying areas from an average of 20% to the desired 40%, which represents a 25 to 30% increase in the animal-carrying capacity of the pasture.

WATER DEVELOPMENT TECHNIQUES

Several techniques have been used for supplying animal drinking water, including wells, earthen ponds, springs, water hauling, pipelines, and water harvesting. There is no "best" method for water development, and all methods have certain advantages and disadvantages. The specific choice selected depends upon factors such as topography, climate, grazing system, type of forage, quantity of forage, relative costs, and type of animals. Following is a brief summary of some of the techniques of supplying animal drinking water.

Springs

The proper development of even a small spring can provide enough water to supply the needs of the livestock using the immediate area (Greenfield 1967). A modification of the free-flowing spring is the horizontal well, a well drilled horizontally into underground water-bearing strata where impervious geologic formations prevented seepage (Welchert and Freeman 1973). The development of natural springs and horizontal wells are relatively low-cost methods of providing animal drinking water. The continuous flow of water from a spring permits the use of relatively small water storage facilities. The total cost of spring-water development depends on local site conditions.

Springs are usually of limited use in supplying water to upland areas,

and some smaller springs and horizontal wells will cease to flow during extended droughts. In some areas, geological conditions are not favorable to springs, or all potential spring sites have been developed to the maximum feasible extent.

Wells

In many areas, the primary source of drinking water is supplied by wells. The water is lifted to the surface with pumps powered by electric motors, gasoline engines, or wind. In areas with essentially continuous winds of sufficient velocity, the windmill pump can provide a continuing water source with minimum labor requirements and relatively small water storage facilities. Windmills are often used in remote locations but are not a reliable method of pumping water in areas where extended periods of calm weather are common.

Wells equipped with electric pumps are limited to locations with electrical service, and gasoline-driven pumps have significant labor requirements for operation and maintenance that limit their use in remote areas. Wells with electric- or gasoline-driven pumps are usually used in combination with relatively large storage facilities to permit water carryover of several days without pumping.

In many locations, a well water supply can be installed for an initial cost of \$3,000 to \$10,000, depending upon the depth to groundwater, size of well, type of pumping system, and the type and size of the water storage facility. In some places, the groundwater is not of suitable quality for drinking, or there is not enough water within feasible drilling and pumping depths (Peden 1971). Well drilling in areas where the groundwater qualities and quantities are unknown can be an expensive gamble. In some areas where large quantities of groundwater are used for irrigation, falling water tables have caused stockwater wells to go dry.

Pipelines

Pipelines are a technique for achieving a dispersed distribution of drinking water from a central water supply. Springs and wells are the primary water source for most systems. Early pipelines were constructed with cast iron or galvanized steel pipe and were relatively expensive, which limited their widespread acceptance and use. The advent of low-cost plastic pipe suitable for underground installation by simple trenching permitted the installation of extensive systems (Peden 1971). If the water source is at a higher elevation than the water needs location, gravity is used to pressurize the system.

The costs of installing a pipeline water distribution system are dependent upon the type and size of the pipe used, land topography, and soil conditions affecting the difficulty of burying the pipe. Energy costs for pumping can be a significant factor when the water source is lower than the outlying watering locations. Pipeline systems usually require a relatively large water storage facility to dampen the effects of high peak usage. Estimated installation costs are \$5,000 to \$15,000 per mile, but maintenance costs on a completed system are usually low. Some buried plastic pipe systems have been damaged by rodents or burrowing animals, and earth movement

and settlement can break the lines and joints or connections. Undetected leaks in pipeline systems can cause a catastrophic loss of the stored water, which renders the entire water system inoperable.

Hauling

Water hauling is an old method of providing drinking water supplies that is still used in many places. Hauling is primarily a means of water supply during periods of extended drought when normal water supplies have gone dry. Some ranchers use water hauling to remote areas as a temporary means to encourage wider dispersion of the livestock. This method is labor intensive, and costs are relatively high, depending upon the quantity of water, distance, fuel costs, and type of tank truck used (Roberts 1971).

Earthen Ponds

One of the earliest techniques used to increase stockwater availability on rangelands was to construct dams across the drainages of small subwatersheds, forming small ponds which were filled by surface runoff from the uplying areas. Trenches or dugouts in natural ponded bottomlands which concentrate the water also constitute a major effort to prolong the availability of summer water. These techniques are still used extensively in many areas, and provide a significant part of the animal drinking water supply.

Earthen stockponds are relatively low-cost and easy to construct using bulldozers or small earthmovers. Estimated construction costs are \$2,000 to \$5,000 for a pond capable of holding 1 to 5 acre-feet of water (0.3 to 1.5 million gallons). Many small ponds are constructed without conducting any significant soil or engineering analysis and depend on the experience of the owner or contractor for proper design and construction.

Newly-constructed stockponds may have relatively high seepage losses. However, with time, the ponds may seal themselves with the fine silts and clays washed into the storage with the runoff water. Ponds in certain types of soils can sometimes be sealed by mixing sodium-based salts, i.e., sodium carbonate (Na_2CO_3), into the soil in the pond bottom (Reginato et al. 1973). A successful chemical seal is achieved if the final seepage rate is less than the evaporation rate (< 0.15 inches/day). Swelling clays (bentonite) is another method of sealing ponds which can be used in some locations.

Most stockponds are gradually filled with sediments and require periodic cleaning to maintain adequate storage capacity. The cleaning process often results in high seepage losses until the bottom is resealed with sediments or is chemically sealed. Stockponds are susceptible to failure if water overtops the dam because of improperly designed spillways or undersized ponds and large runoff events. Spillways on unconsolidated soils may erode and fail if used at frequent intervals unless stabilized channels or erosion-resistant grassed waterways are provided.

The reliability of stockponds for animal drinking water supplies is influenced by the amount of runoff water from the uplying areas, seepage and evaporation losses from the pond, and the frequency of runoff-producing storm events. Seepage and evaporation losses can be significant factors,

even on a pond that can hold water for several months. In arid and semiarid regions, the evaporation rate from a stockpond can exceed 100 inches per year (Cooley 1970). The high evaporation and seepage losses cause many ponds to go dry during the hot part of the year, which limits their usefulness as a water supply for specialized grazing systems (Greenfield 1967) that require utilization during the dry seasons. Water used by livestock frequently represents only a small percentage of the water lost by evaporation and seepage.

Water Harvesting

Water harvesting is the technique of collecting water from relatively small areas (catchments) that are chemically treated or covered with an impervious membrane to reduce infiltration and increase precipitation runoff. The collected water, stored in a tank, is used for livestock, wildlife, or domestic drinking supplies (Fraser 1980). An idealized sketch of a water-harvesting system is presented in figure 4. Water-harvesting techniques are being used to provide livestock and wildlife drinking water on rangelands where traditional methods of water supply are not present or development is not feasible (Cooley et al. 1978).

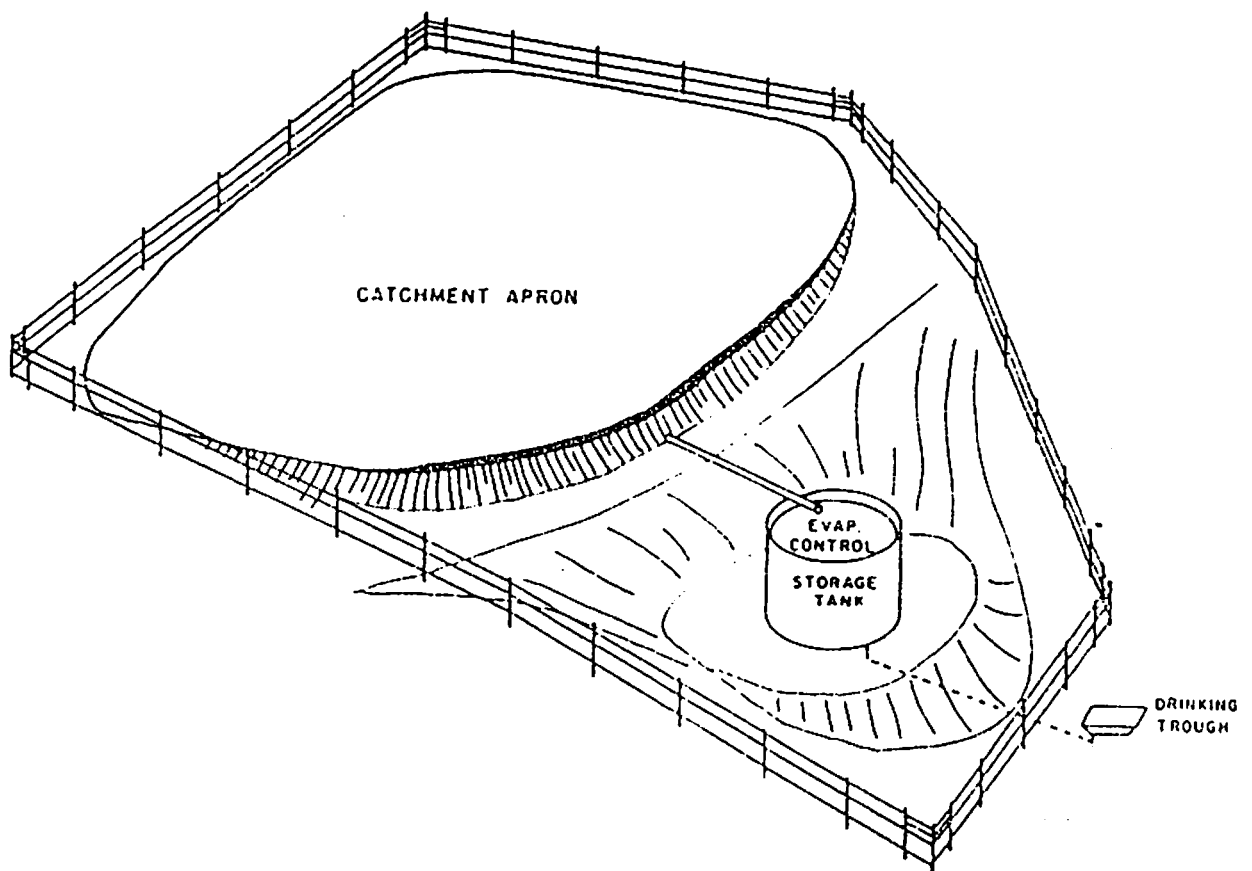


Figure 4. Sketch of a typical water-harvesting system for supplying animal drinking water.

Several methods are used to cover the catchment area (Frasier et al. 1979). Table 2 is a listing of several catchment treatments which are being used on operational water-harvesting systems. Included in the table is a brief summary of site factors, costs, life, and runoff efficiency for each treatment. The asphalt-fabric treatment is presently being used on operational catchments in the hot, arid climate of the southwestern United States, cold mountainous regions of Colorado and New Mexico, and the humid, tropical regions of Hawaii. Table 3 lists some of the types and costs of water storages used on water-harvesting systems.

Table 2. Approximate site requirements, costs, and performance data for field-tested catchment construction materials.

TREATMENT	CATCHMENT SLOPE		SOIL TEXTURE					AIR TEMP.		CATCHMENT SURFACE		APPROXIMATE INSTALLATION COST/YD ² ON PREPARED SITE		APPROXIMATE AVERAGE LIFE IN YEARS (W/GOOD MAINTENANCE)	DESIGN RUNOFF PERCENTAGE	
	3-5%	5-10%	SILT	SILT LOAM > 20% SAND	SANDY LOAM	SAND AND LOAMY SAND	CLAY AND CLAY LOAM	FREEZING	SUMMER > 90°F	SUMMER < 90°F	ROUGH	SMOOTH	MATERIALS			LABOR
ASPHALT-FABRIC	X	X	X	X	X	X	X	X	X	X	X	X	2.00	.50	20	95+
GRAVEL COVERED SHEETING	X	0	X	X	X	X	X	X	X	X	0	X	1.75	.80	15	65+
PARAFFIN WAX	X	0	0	X	1/	0	2/	X	X	0	X	X	1.00	.10	7	75+
ARTIFICIAL RUBBER MEMBRANE	X	X	X	X	X	X	X	X	X	X	0	X	10.00	.50	15	95+
SHEET METAL COVERING	X	X	X	X	X	X	X	X	X	X	X	X	15.00		20	95+
CONCRETE	X	X	X	X	X	X	X	X	X	X	X	X	20.00		20	60+

- 0 PROBABLE FAILURE
- X PROBABLY SUCCESSFUL
- 1/ TREATMENT SHOULD WORK IF CLAY IS NON-SWELLING
- 2/ TREATMENT MAY WORK IF CLAY IS DEFLOCCULATED
- 3/ BASED ON 1980 MATERIALS COST
- 4/ BASED ON ESTIMATED LABOR COST OF \$10.00/HOUR

No one method is best suited for all situations, and each water-harvesting system must be specifically designed to match the local site conditions. The specific techniques and materials used depend upon factors such as soil type, topography, general climatic conditions, quantity of water required, labor and equipment available, and the frequency and size of precipitation events (Frasier 1975). The costs of providing a water supply by water-harvesting techniques are minimized by matching the size of the catchment and storage tank to the precipitation patterns and water requirements (Frasier and Myers In Press). Typical water-harvesting systems used

to provide livestock water consist of a catchment area of 700 to 2,500 square yards with storage facilities of from 10,000 to 80,000 gallons. Installation costs, including fencing, piping, drinking troughs, etc., are \$7,000 to \$25,000 per system. With proper sizing of the catchment and storage to match forage production, precipitation patterns and land topography, water-harvesting techniques can be used as a range management tool to maintain proper utilization rates. All water-harvesting systems require periodic maintenance to insure optimum performance.

Table 3.--Types and approximate costs of water storages used on water-harvesting systems.

Tank Type	Approximate Cost ¹ in \$/1000gallons
Prefabricated Tanks (wood, steel, fiberglass, butyl bags, etc.)	200 - 400
Steel Rim	
(a) Elastomeric lining	200
(b) Polyvinyl chloride plastic sheeting	160
(c) Composit lining of asphalted fabric- polyethylene-asphalted fabric	150
(d) Concrete	100 - 200
Excavated Earthen Tank	
(a) Exposed elastomeric lining	130
(b) Exposed composit lining of asphalted fabric-polyethylene-asphalted fabric	100
(c) Buried lining	130
Plastered Concrete	110

¹Based on 20,000-gallon tank; labor costs for installation estimated at \$10/hr.

ECONOMICS OF WATER DEVELOPMENT

Workman and Hooper (1968) conducted an economic evaluation of various rangeland management practices such as trail construction, fencing, salting, herding, and water development to improve cattle distribution on mountain ranges of the Intermountain area. They found that 85 to 150 additional animal unit months (AUMs) were obtained from each new water development. Based on a grazing fee of \$0.60/AUM at 4% interest for 10 years, they concluded that, on Federal lands, only low-cost water developments (springs, earthen ponds) could be economically justified by the increased animal production. The more expensive water-harvesting techniques were probably a sound investment for a private operator on public (state) or private lands. Greenfield (1967), using net AUM values of \$1.50 to \$4.50 at 5% interest for 10 years, showed that water-harvesting techniques were potentially an economical,

favorable practice if sufficient previously unusable forage was available. An added monetary benefit frequently omitted is the improvement of previously overgrazed areas which result from grazing pressure relief brought about by redistribution of grazing.

Construction costs of water development and interest rates have increased by a factor of 2 to 4 since these studies were completed. Livestock prices have also risen since then, but at a significantly slower rate (Gray 1979). This has added to the burden of the range managers to justify the construction of additional water supplies based on a strict economic analysis of the increase in meat production from the land. As a result, most new rangeland water developments on private land have been installed with the financial assistance of various governmental cost-share programs. Public rangeland managers have found it necessary to charge some of the water development costs to various wildlife benefits.

Many users of our rangelands receive benefits derived from improved management of the land. It is very difficult to assign a cost benefit to the recreational user or the hunter of wildlife and waterfowl. It is also unrealistic to insist that a practice must be paid for only by the benefits to the livestock operator. One of the greatest benefits to be derived from proper rangeland management is the protection of the soil resource. The soil is most easily protected by maintaining a plant cover on the land. Range water development is a viable means of improving the utilization of the forage resource and still protecting the soil resource.

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Supplement to Paper
Development of Water for Grazing Management

by

Gary W. Frasier

Because the initial costs of water development are relatively expensive, the cost benefits based only on the potential increase in animal carrying capacity is discouraging at the present.

Estimates of water development cost (1978) are as follows:

spring development	-	\$1000 +
wells	-	\$3000-10000
pipelines	-	\$5000-15000
earthern ponds	-	\$1000-5000
water harvesting	-	\$7000-25000

Using compound interest annuity tables and a project life of 20 years, an interest rate of:

- 6% needs an annual return of \$ 88 per \$1000 of improvement
- 10% needs an annual return of \$115 per \$1000 of improvement
- 15% needs an annual return of \$160 per \$1000 of improvement