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NEW INNOVATIONS IN WATER COLLECTION AND STORAGE

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Summary

Increasing the availability and distribution of livestock and wildlife drinking water supplies will improve the performance of the animals and the production of the forage or plant resources in the area. Common water development techniques for rangelands include wells, earthen ponds, spring development, water hauling, pipelines, and water harvesting. There is no method which is ideally suited for all areas. Each technique has advantages and disadvantages which must be considered. The specific technique used will depend upon factors such as topography, climate, grazing system, type and quantity of forage, type of animals, and costs. Providing animal drinking-water supplies is an expensive range improvement practice, but there are numerous direct and indirect benefits. It is often overlooked that the recreational user and hunter of wildlife are prime beneficiaries of improved range-water supplies. These users should be included in any cost/benefit economical analysis. One of the greatest benefits is the protection of the soil resource through proper management and utilization of the forage resource.

Techniques of Range Water Development

It has long been recognized that much of our rangelands have insufficient numbers of animal drinking water supplies. In many areas, the distribution of natural water supplies, such as springs and rivers, is not adequate to allow animals easy access to all portions of the grazing areas. This results in overgrazing adjacent to the water, while areas further away are unused. Herbel et al. (1967) reported that cattle would graze at distances of up to 3.5 miles from drinking water supplies. For many places, this is too great a travel distance for optimum animal performance. When animals spend an appreciable time traveling to water, there is less time available for grazing and feed digestion (Squires 1978). Reynolds and Martin (1968) recommended that permanent water sources be a maximum of 4 to 5 miles apart on flat land, 3 miles on rolling land, and 1 to 2 miles on rough terrain. Sneva (1979) suggested that drinking water supplies should be spaced 1/4 to 3/4 miles apart to achieve the greatest uniformity of grass utilization. Frasier (1981) showed that when the average animal travel distance was reduced from 1 mile down to 1/2 mile, the improved uniformity in forage utilization alone allows the animal-carrying capacity to be increased by 30%. This paper summarizes some of the various techniques that are being used to provide animal drinking water suppies.

Common water supply techniqes that are being used include wells, earthen ponds, spring development, water hauling, pipelines, and water harvesting. There is no "best" method that is universally applicable.

All techniques have certain advantages and disadvantages. The specific technique selected will depend upon factors such as topography, climate, grazing system, type and quantity of forage, type of animals, and costs (Frasier and Myers 1983). Table 1 lists some of the advantages and disadvantages of each method along with comparative costs.

Table 1. Methods of supplying animal drinking water on rangelands[1]

Water supply method	Initial cost estimate	Advantages	Disadvantages
Wells	\$3000 - \$10000[2]	1. Dependable water supply in many areas. 2. Low annual costs.	1. Some areas not geologically suitted. 2. Pumping costs can be a factor
Earthen Ponds	\$1000 - \$5000	1. Low initial and annual costs.	1. Seepage and evaporation losses a factor. 2. Many areas not geologically suited.
Springs	\$1000 - \$3000	1. Low initial and annual costs.	1. Many areas not geologically suited.
Hauling	Highly Variable	1. Highly mobile. 2. Low initial cost if existing equipment can be used.	1. Labor intensive. 2. High annual costs. 3. Not practical for extended periods.
Pipelines	\$5000 - \$15000[3]	1. Dependable water supply in many areas. 2. Low annual costs.	1. Requires a central water source. 2. Expensive over long distances.
Water Harvesting	\$7000 - \$25000	1. Potentially suited for any area.	1. High initial costs. 2. Requires a scheduled maintenance program. 3. Some treatments susceptible to mechanical damage.

[1]Adapted from Frasier (1984).
[2]Water storage facility not included.
[3]Based on distances of 1 - 2 miles.

Wells: In many places, wells are the primary water source. If winds are of sufficient duration, dependability, and velocity, windmills are an effective means of pumping the water. Pumping systems are being developed which utilize direct current submersible pumps powered by photovoltaic cells (solar). These systems will potentially operate in locations where wind speeds are too low for windmill operation (McKenzie 1985). In some situations, pumps can be powered by electric motors or gasoline engines. These approaches have a limited application for range water supply systems. In areas of extensive pump irrigation, falling water tables have caused some shallow stockwater wells to go dry. If ground water qualities and quantities are unknown, supplying new range water by well development can be an expensive gamble.

Earthen Stock Ponds: Earthen stock ponds have long been a major source of animal drinking water in many areas. They are relatively low cost and easy to construct. Newly constructed ponds may have high seepage losses. In some cases, the ponds will gradually seal themselves with fine silts and clays washed into the storage area with the collected runoff water. Sealing leaking stockponds by mixing expanding-type clays (bentonite) into the soil on the pond bottom have been tried in most places. Bentonite treatments often fail after a few years because the sodium on the bentonite clays becomes replaced by calcium from the stored runoff water, and the clays lose the ability to expand and seal the soil pores (Dirmeyer and Skinner 1965). On some soil types, it may be possible to reduce seepage losses from the ponds by mixing sodium-based salts such as sodium carbonate into the soil in the pond bottom (Reginato et al. 1973).

Most stockponds will gradually fill with sediments, and require periodic cleaning to maintain adequate storage capacity. The cleaning process often destroys the seal of the pond, causing high seepage losses. Many stockponds are damaged or destroyed each year by water overtopping the dam because of improperly designed spillways or unusally large runoff events. In some areas, it is illegal to construct a new stock pond without a prior water right.

Stock pond reliability as a means of animal water supply is influenced by the amount of runoff from the upland area, the frequency of runoff-producing events, seepage losses, and evaporative losses. In a practical sense, a successfully sealed pond is one where the seepage rate equals the evaporation rate. In the warm regions of the world, evaporative losses from an open surface can be 6 to 10 feet a year. When this is coupled to seepage losses, it is not unusual to have a total water loss of over 20 feet per year. To offset the water losses from seepage and evaporation, it is usually necessary to oversize the pond. As a result, the water used by the livestock and wildlife frequently represents only a small percentage of the total water collected.

Spring Development: Spring developments require favorable geological conditions, and are effective for supplying water to lower lying areas. Sometimes the water is pumped from the spring to a higher elevation. A modification of the standard free-flowing spring development is a well drilled horizontally into an undergound water-bearing strata. For this to be successful, a good knowledge of the geology of an area is required. Horizontal wells and spring developments are relatively low-cost methods of water supply when local site conditions are favorable.

Water Hauling: Water hauling is an old method of water supply that is still used in some locations during periods of extended droughts when normal water supplies are dry, and it is not feasible to remove the animals from the area. Some ranchers have used water hauling to remote areas on a temporary basis to encourage wider dispersion of livestock. This method of water supply is relatively expensive and labor intensive, depending upon the quantity of water required, distance, fuel costs, and type of tank truck available (Roberts 1971).

Pipelines: Pipelines from a central water supply are effective in some areas. Pipeline installation costs are dependent upon the type and size of the pipe, land topography, and soil type. If the water source is lower than the area of needed water, the pumping costs can be a factor. On properly installed systems, the annual maintenance requirements are low. Some problems have been reported of damage to buried plastic pipe systems by burrowing animals or earth movement. Undetected leaks can cause a catastrophic loss of the stored water.

Water Harvesting: Water harvesting is a method of water supply that is being used to provide livestock and wildlife drinking water in areas where other methods are not feasible (Cooley et al. 1978). Water harvesting is simply the collection of precipitation from a small catchment area that is treated or covered with a membrane to reduce infiltration. The collected water is stored in a suitable container until it is needed. Contrary to some beliefs, it is not an inexpensive method of water supply.

A water-harvesting system is the complete facility for collecting and storing the water, including all peripheral equipment such as drinking troughs, fencing, evaporation control, etc. There is no "best" or "standard" type or size of water-harvesting system. The specfic 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 the precipitation events (Frasier and Myers 1983). Typical water-harvesting systems used for providing livestock drinking water consist of a catchment area of 700 to 2500 sq. yds., with storage facilities of 10,000 to 80,000 gal.

Water Harvesting Techniques

Catchment area: The catchment area is the component of the water-harvesting system used for collecting and concentrating the precipitation. Any area that is reasonably impermeable to water infiltration can be used as a catchment surface. Large expanses of rock outcroppings are natural surfaces that can be used. Paved highways and roofs of buildings are examples of surfaces designed for other uses which can be used for water collection. For most water-harvesting systems, the catchment area is a specfic site that is cleared of all vegetation, shaped, smoothed, and then treated or covered to stop water infiltration. Table 2 lists several catchment treatments which are being used on operational systems. Included in the table are some onsite factors that must be considered, costs, life, and runoff efficiency for each treatment.

Table 2 .--Site requirments, costs, and performance data for some water-harvesting catchment treatments.

Treatment	Site Conditions		Costs[1]			
	Maximum Slope	Surface	Materials	Labor	Life	Runoff Efficiency
	(%)		($/yd^2)	($/yd^2)	(yrs)	(%)
Asphalt-fabric	10	all	$2.00	$0.50	20	95+
Gravel-covered sheeting	5	smooth	1.75	.80	10	85+
Paraffin wax	5	selected soils	1.00	.10	10	75+
Artificial rubber membranes	10	smooth	10.00	.50	20	95+
Sheet-metal coverings	10	all	15.00	.50	20	95+
Concrete	10	all	20.00	.80	20	60+

[1]Approximate onsite costs on a prepared site. Materials are based on 1980 costs. Labor is estimated at a rate of $10.00 per hour per man.

An effective treatment that is being used in many places is a membrane of asphalt saturated fabric. The fabric, a random-weave fiberglass matting or a synthetic polyester filter matting, is unrolled on the prepared catchment surface and saturated with an asphalt emulsion. Three to 10 days later, a final asphalt sealcoat is brushed on the surface. After the asphalt has had an opportunity to harden, (2 to 6 months) the covering is relatively resistant to damage by wind, animals and weathering processes (Myers and Frasier 1974).

Many types of plastic sheetings have been investigated as potential soil coverings for water-harvesting catchments. Most of these treatments failed in field installations because of mechanical damage to the exposed sheeting by wind or animals. Covering the sheetings with a shallow layer of clean gravel has been an effective method in some locations. The sheeting is the waterproof membrane, and the gravel protects the sheeting from mechanical damage. This treatment does require a good periodic maintenance program to insure that the gravel remains in place.

Paraffin wax is a chemical soil treatment that is being used in limited locations. Molten refined paraffin wax is sprayed on a prepared catchment surface. As the sun heats the surface, the wax remelts and moves deeper into the soil, coating each individual soil particle with a thin wax coating, rendering the soil water repellent. This treatment is best suited to soils containing less than 20 percent clay and sites where the soil temperatures will exceed the melting point of the wax during some part of the year (Frasier 1980).

Many conventional construction materials, such as artificial rubber sheeting, sheet metal, and concrete, can be used on water-harvesting catchments. In the 1950's, many catchments were covered with sheetings of artificial rubber (butyl). Improper placement, plus susceptibility to damage by wind and animals, destroyed many of these units. Roofs of sheet metal have long been used to collect water. Costs can be reduced by placement of the sheeting on the ground surface. Under some conditions, concrete is a viable treatment. Concrete surfaces will become partially porous as the concrete ages and absorbs some of the initial precipitation which reduces the overall runoff efficiency. Large expanses of concrete will crack, necessitating periodic sealing of the cracks with some type of crack sealer. These materials are all relatively expensive, but when properly installed and maintained, have long lives, and may be the best treatment for some locations.

Water Storage: Water storage is a major expense with any water-harvesting system, and often represents 50% of the total cost. Any container which prevents seepage and evaporation losses is a potential water storage facility. Table 3 lists some general types and costs of water storages which have been used.

There is an almost infinite number of types, shapes and sizes of wooden, steel or reinforced plastic storages. Costs and availability in a given area are the primary factors for determining the suitability of these types of storages. Artificial rubber (butyl) bags have been used in limited installations. They have not been successful on sites in remote areas because of damage by animals.

A storage type used on many systems consists of a steel rim tank with an impermeable liner or a concrete bottom. Tank liners constructed from plastics must have protection from sunlight to protect the liner from deterioration.

Another storage that is very effective and relatively inexpensive is the plastered concrete storage. This storage consists of filling the wire mesh of the tank walls with a cement plaster. This storage construction does require a significant amount of hand labor.

Unlined earthen storage pits or ponds are usually not a good means of storing water for a water-harvesting system unless seepage losses can be controlled. Exposed liners of plastic or artificial rubber are susceptible to damage from wind, sun, animals, and plants. Under some situations,the liners can be covered with a layer of soil.

Table 3. -- Types and approximate costs of water storages.

Tank type	Cost[1]
	($/1000 gal.)
Prefabricated (wood, steel,fiberglass,butyl bags, etc.)	200 - 400
Steel rim with:	
a) Elastomeric lining (artificial rubber)	200
b) Plastic lining (polyvinyl choride)	160
c) Composite lining--asphalt fabric:polyethylene: asphalt fabric	150
d) Concrete bottom	100 - 200
Plastered concrete (ferro-cement)	110
Excavated earthen tank with:	
a) Exposed elastomeric lining (artificial rubber)	130
b) Exposed composite lining--asphalt fabric:polyethylene: asphalt fabric	100
c) Buried plastic (polyethylene or polyvinyl choride)	130

[1] Based on a 20,000-gallon tank. Costs are for on-site labor and materials. Material costs based on 1980 prices. Labor costs estimated at $10/hr per man.

Evaporation control: Controlling evaporative water losses from the water storage is one of the most economical methods of maintaining an adequate water supply, and should be an integral part of any water-harvesting facility. Roofs over the storage are a common technique. The roof can be extended over the sides and inverted to act as part of the catchment area. Floating covers of low density synthetic foam rubber sheeting are an effective means for controlling evaporation from vertical-walled storages. Cooley et al. (1978) reported that a floating cover would save water at a cost of less than one-fifth the cost of collecting the water. Evaporation control on sloping-sided storages or ponds is difficult to implement, because the water surface area changes as the depth of water changes (Frasier and Myers 1983).

Maintenance: Failure to maintain a water-harvesting system will result in premature failure. A maintenance program must be established and followed, even during periods when the collected water is not being utilized. Most water-harvesting systems can be adequately maintained with twice-a-year inspections plus the immediate repair of any problem detected at other times. Inspection and repair trips usually require less than 4 hours of labor per visit. The maintenance program must be matched to the specific system. Some types of catchment treatments and storage facilities require more frequent and intense maintenance than others (Frasier and Myers 1983)

Economics of Water Development

In many places, it may be necessary to instigate some type of major range improvements before the proper management can be implemented. Water development is one of the key improvements needed in many areas, and it is also one of the most expensive. 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,and
15% needs an annual return of $160 per $1000 of improvement.

It is very difficult to measure the benefits of range water developments to wildlife and the recreational user. It is also unreasonable and unrealistic to insist that the total water development costs be charged exclusively to the livestock operator. On public lands with multiple uses, water development costs must include benefits to wildlife and recreation before they are economically justifiable. The same reasoning should be utilized for determing the benefits to the private rancher. It must be realized by all that range water development is a viable means of improving the utilization of the forage resource and at the same time protecting the soil resource. Protecting the soil resource by maintenance of the plant cover may be the greatest benefit derived from the proper management of our rangelands.

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