STATE OF NEVADA
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES
DIVISION OF WATER RESOURCES
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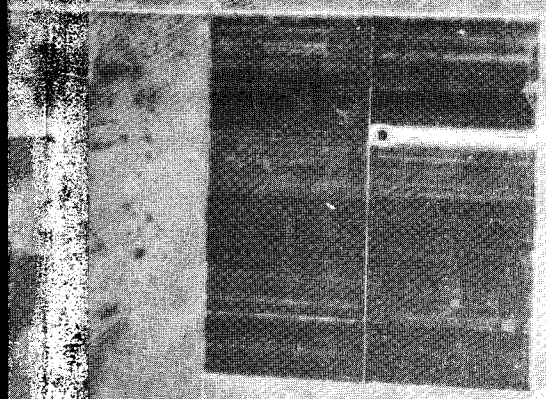

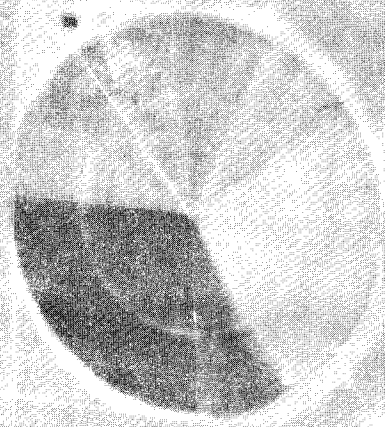

WATER RESOURCES-INFORMATION SERIES

REPORT 24

WATER REQUIREMENT AND EFFICIENCY OF SPRINKLER IRRIGATION OF ALFALFA, SMITH VALLEY, NEVADA—A CASE HISTORY

By
F. EUGENE RUSH

Prepared cooperatively by the
UNITED STATES DEPARTMENT OF THE INTERIOR
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1976

STATE OF NEVADA

DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

DIVISION OF WATER RESOURCES

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PHOTOGRAPH

Cover photograph. Near-vertical aerial photograph taken during summer of 1972. The irrigated tract evaluated is the dark rectangular area in the left-central part of the photograph. North at top.

CONVERSION FACTORS

For those readers who may prefer to use metric units rather than English units, the conversion factors for terms in this report are listed below:

English unit	Metric unit	Multiplication factor to convert from English to metric quantity
Acres	Square metres (m^2)	4,047
Acre-feet	Cubic metres (m^3)	1,233
Fahrenheit temperature (°F)	Celsius temperature (°C)	(a)
Feet (ft)	Metres (m)	0.3048
Gallons (gal)	Litres (l)	3.785
Gallons per minute (gal/min)	Litres per second (l/s)	0.06309
Horse power	Kilowatts (kw)	0.746
Inches (in)	Centimetres (cm)	2.540
Miles (mi)	Kilometres (km)	1.609
Parts per million (ppm)	Milligrams per litre (mg/l)	(b)
Pounds (lb)	Kilograms (kg)	0.4536
Pounds per square inch (psi)	Kilograms per square centimetre (kg/cm^2)	2.926
Tons (short)	Tonnes (t)	0.9072

a. $°C = (5/9)(°F-32)$.

b. The two units are virtually equal for dissolved-solids contents less than about 7,000 ppm.

WATER REQUIREMENT AND EFFICIENCY OF SPRINKLER IRRIGATION OF ALFALFA, SMITH VALLEY, NEVADA- A CASE HISTORY

By F. Eugene Rush

ABSTRACT

An area of 157 acres of alfalfa was sprinkler-irrigated for a period of 173 days in 1973. About 5.4 tons of hay per acre were produced with a water application of 41.9 inches, resulting in an application rate of 7.8 inches per ton. Compared with experimental results, the water use was about 130 percent of the net water requirement. A minor change in irrigation operations would produce a water use of about 120 percent of the net requirement.

INTRODUCTION

Irrigation of agricultural land has been the dominant use of water in Nevada. This use and others are expanding and probably will continue to do so into the long-term future.

The demand for water has raised questions as to what are the best ways to use the limited water resource and how efficient various uses are. The overall objective of this brief study is to describe the operation of a sprinkler irrigation system in Smith Valley of western Nevada (fig. 1), and compare the efficiency of these irrigation practices with the findings of studies made under experimental conditions.

The irrigation system evaluated is on the "Jessen Ranch," which at the time of this study was owned and operated by William G. Walker. This particular farming operation was selected because: (1) extensive and accurate records of land and water use were available; (2) it appeared that high quality and constantly maintained irrigation equipment was used; (3) it appeared that greater-than-average care was exercised in irrigating and farming the land; and (4) pumping rates were periodically checked by the author and are the same as measured by the owner.

Scope

Rates of water use by crops vary greatly because of many factors, such as type of crop, water-application procedure, soil texture, climate, water quality, water cost, the ability of the farmer with respect to irrigation, and the suitability of the irrigation method and equipment to the crop and land. This report evaluates and documents the overall crop yield per unit of water used on one farm, growing alfalfa for hay. It is presented as a case study to document the potential, under specific conditions, for attaining near optimum crop yields per unit of net water requirement in the agricultural areas of western Nevada.

Background Information

The irrigated area described in this report is on 157 acres in the NW sec. 31, T. 12 N., R. 24 E., Mount Diablo base line and meridian (fig. 2). The land is at an altitude of about 4,800 feet on the floor of Smith Valley.

Smith Valley is arid to semiarid. Average annual precipitation on the valley floor ranges between 5 and 8 inches. Most of this precipitation falls in the period from November to March as snow and rain. The growing season, averaging about 125 days based on a killing-frost temperature of 28°F, is generally cloudless, breezy in the afternoons, hot and dry. The average potential lake evaporation is about 48 inches per year (Kohler and others, 1959, pl. 2). Results of tests on topsoil from the irrigated area are given in table 1.

The base year for the case study and evaluation is 1973. Based on a minimum temperature of 28°F, the growing season extended from May 1 to October 3, a total of 156 days. The frost-free period was 150 days.

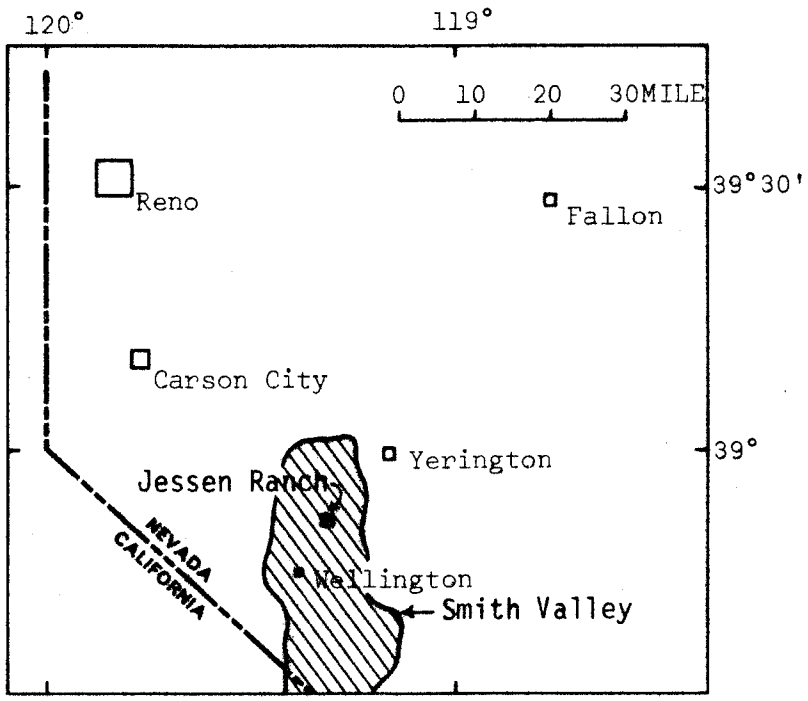

Figure 1.--Location of the Jessen Ranch.

Table 1.--*Results of topsoil tests*

[Tests made by University of Nevada, Soil and Water Testing Laboratory]

Test 1/	Results
Salinity hazard	Very low
Sodium hazard	Low to very low
pH	Within optimum range of 6.2 to 7.5
Texture	Mostly moderately coarse (sandy loam to very fine sandy loam)
Calcium carbonate	Absent
Phosphorus	Moderate probability of better growth with addition of phosphorus. Test values ranged from 10 to 17 ppm (parts per million)
Potassium	Possibly deficient. Test values ranged from 103 to 152 ppm

1. Tests run on four samples. Samples collected on March 9, 1971.

FARM OPERATION

Early in 1969, the native vegetation, mostly big sage, was cleared from the land and barley was planted. In 1970, 50 acres of alfalfa seed (Northrup King Registador 1/) was planted; wheat and barley were grown on the remaining 107 acres. In 1971, the entire 157 acres was planted to alfalfa. Following the last cutting in 1972, the cropland was grazed by sheep.

Water was obtained from a 14-inch diameter, 540-foot deep well that is centrally located on the land (fig. 2). No other sources of water were available. Depth to the water table was about 50 feet beneath the property. The temperature of the pumped water, measured at the well head, was about 80°F.

The well pump discharged into a pond from which water was pumped by two 30-horsepower electric pumps to a 2,600-foot long buried main irrigation line extending north-south through the center of the field. The main line was equipped with fifty-seven 4-inch risers spaced 46 feet apart. Three pair of wheel-roll laterals were used by connecting to the risers. Three of the laterals, used on the downwind (east) side of the main line, each had 40 full-circle sprinklers with 1/8-inch nozzles plus two part-circle sprinklers with 5/32-inch nozzles at each lateral end. The other three laterals, used on the upwind side of the main line, were 20 feet longer and had one additional sprinkler with a 1/8-inch nozzle.

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1. The use of the brand name in this report is for identification purposes only and does not imply endorsement by the U.S. Geological Survey.

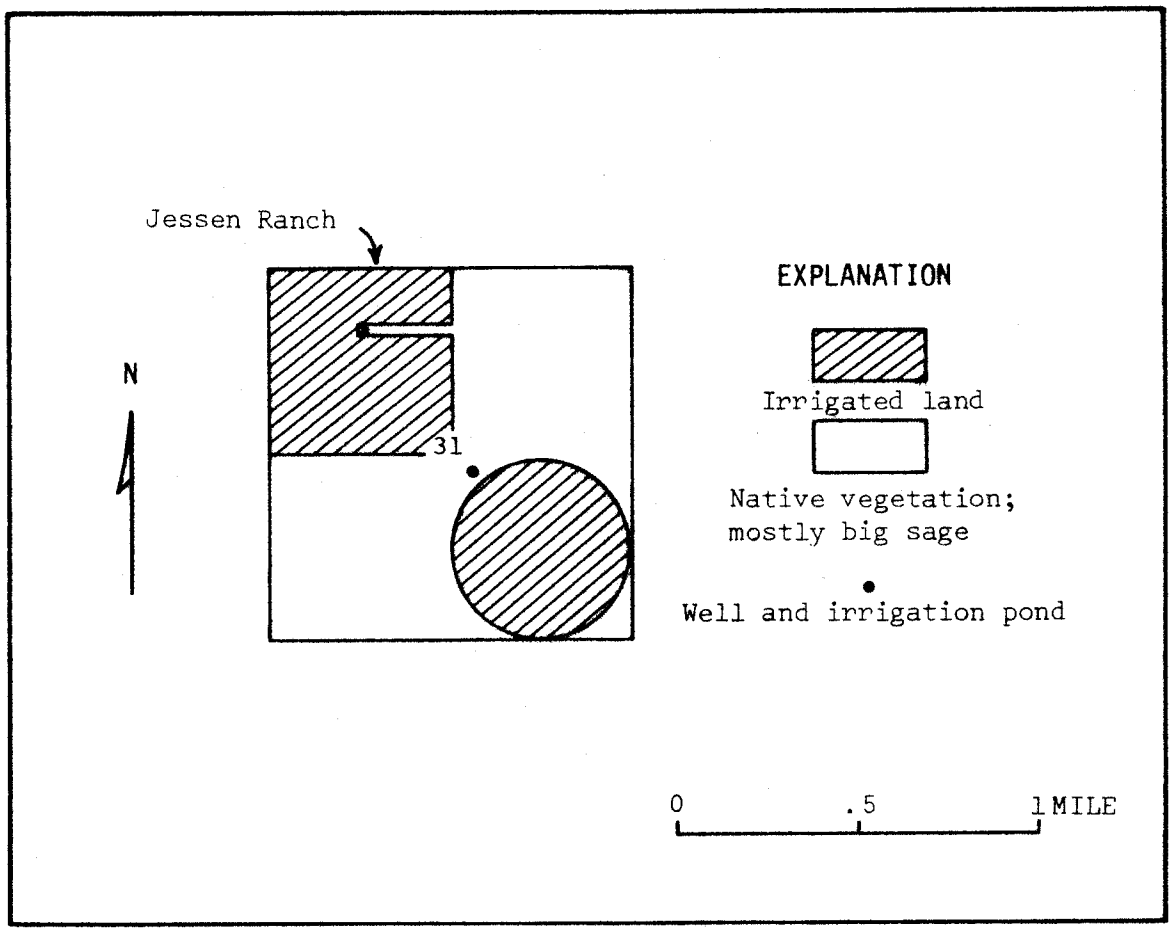

Figure 2.--Irrigated land in section 31, T. 12 N., R. 24 E., Smith Valley, Nevada.

As there are 57 risers, each pair of laterals used 19 risers for its part of the field. Laterals were moved each 12 hours; therefore, taking 9½ days to irrigate the entire field, which also was the irrigation interval for the crop.

The water-distribution system had a pressure of 70 psi (pounds per square inch) at the risers. The effective pressure at the sprinkler nozzles averaged 65 psi. A 1/8-inch nozzle at 65 psi pressure has a spray radius of about 45 feet, which is approximately equal to the distance between the risers. Therefore, an area between two lateral locations received water from both. Allowing for the time required to move and roll back the laterals, the effective time of sprinkler operation was 20 hours per day under 24-hour operation.

A 1/8-inch sprinkler nozzle, at 65 psi discharges 3.7 gal/min (gallons per minute) and a 5/32-inch, 5.7 gal/min. The total of 243 1/8-inch nozzles discharged 900 gal/min and the twelve 5/32-inch nozzles, 68 gal/min. As all six laterals were operated at the same time, the total sprinkling rate was about 970 gal/min, or an average rate of approximately 0.27 inches per day with 24-hour operation.

In 1973, irrigation was started on April 8 and continued to September 28, a total of 173 days. The last cutting of alfalfa was started on October 1. During the irrigation period, 41.4 inches of water was applied to the land and an additional 0.41 inch of precipitation was measured. A total of 848 tons of alfalfa hay was bailed on the 157 acres of cropland (5.4 tons per acre). Total water application was 546 acre-feet, including precipitation, which is equivalent to a total water depth of 3.5 feet. Table 2 is a summary of irrigation and crop yield.

Based on the need determined from soil tests, liquid fertilizer was added to the irrigation water and applied to the cropland through the sprinkling system. The fertilizer had a composition of available nitrogen, 7 percent; phosphate, 21 percent; and potash, 7 percent. It was applied following each of the first three cuttings at the rate of 2,900 pounds (323 gallons) per application.

The rate of water application in 1973 was based on soil-moisture monitoring during 1970 and 1971. During those years, "Irrometers" (tensiometers) and augered observation holes were used to monitor soil-moisture conditions. The ranch owner determined from observations that yield reduction would result from a saturation of less than about 50 percent. He considered a saturation of 75 to 80 percent at an 18-inch depth to be optimum, and attempted to restrict percolation to the upper 4 feet of soil.

Table 2.--*Summary of irrigation and crop yield, 1973*

Time periods (1973) From	To	Irrigation days	Average hours per day (net)	Total applied water per day (inches) 1/	Total applied water in period (inches)	Water applied per cutting (inches)	Tons of alfalfa per cutting per acre	Inches of water per ton of alfalfa
Apr. 8	Apr. 28	20	7	0.10	1.9			
Apr. 28	June 2	35	20	.27	9.6	12.8	1.40	9.1
June 2	June 14	a 12	b 15	.21	c 2.5			
June 14	July 12	28	20	.27	7.7	10.2	1.57	6.5
July 12	July 24	a 12	b 15	.21	c 2.5			
July 24	Aug. 17	24	20	.27	6.6	9.1	1.51	6.0
Aug. 17	Aug. 29	a 12	b 15	.21	c 2.5			
Aug. 29	Sept. 28	30	20	.27	8.2	9.4	.91	d 10.3
Total, irrigation season (rounded)		173	--	--	41.5	e 41.9	5.4	7.8

1. Application rate 0.0137 inch per hour.

a. Haying period. Water applied to part of field not being worked.

b. Net operation was 75 percent of normal 20-hour day for the 12-day period.

c. On the average, half the water was applied prior to cutting and half was applied after cutting.

d. Includes excess water to sustain crop during winter and to leach salts.

e. Includes 0.4 inch of precipitation.

RESULTS OF OTHER EVALUATIONS

Alfalfa has been grown in other areas under experimental conditions by irrigation-research specialists. Many of these studies used large, buried, open-top tanks in which the crop was surface-irrigated (rather than sprinkler-irrigated). The tanks were used because the water available to the crop could be controlled and accurately measured, and evapotranspiration requirements could be accurately measured.

Houston (1950, p. 21), using the Blaney-Criddle method which does not consider the method of water-application, reports that the average annual consumptive use of water by alfalfa in Smith Valley is 21 inches, including 1 inch from precipitation during the growing season. This is the amount of water used in transpiration to build plant tissue, plus that evaporated from adjacent soil or intercepting plants, according to Houston. The growing season during 1973 was about 25 percent longer than the long-term average, based on temperature data for Yerington, 13 miles northeast in an adjoining valley. Adjusting for the longer and warmer 1973 season and using the Blaney-Criddle method, the consumptive use would be about 27 inches. For the 1973 5.4-ton-per-acre alfalfa crop, this would be a consumptive use of about 5.0 inches per ton of alfalfa.

Using a modified Blaney-Criddle method developed by the U.S. Soil Conservation Service (SCS), Thomas G. McIntyre of the SCS (oral commun., 1973) computed that the consumptive use for alfalfa at Wellington (7 miles southwest of Jessen Ranch in Smith Valley) averages 29 inches, including growing-season precipitation. Using McIntyre's computations, and adjusting for the longer and warmer 1973 season, as above, the consumptive use per ton of alfalfa would be 6.9 inches.

Two tank studies conducted by Houston (1955, table 4) at Reno (fig 1), which has a similar climate and growing season to that in Smith Valley, indicated that the consumptive use, not including precipitation, was 4.9 and 5.6 inches per ton of over-dried alfalfa. Two adjustments should be made in these values: (1) a small amount of growing-season precipitation should be added to determine the total consumptive-use requirement, and (2) Houston's alfalfa tonnages should be revised to allow for normal moisture content. Generally, baled alfalfa has a moisture content of 10 to 12 percent, according to Charles Speth of the University of Nevada (oral commun., 1974). Making these small adjustments, the resulting computed consumptive uses are 4.5 and 5.2 inches of water per ton of alfalfa.

Tank experiments by Tovey (1963) at Reno, showed a consumptive use for alfalfa of 4.9 inches per ton.

Research done near Fallon by Guitjens and Mahannah (1972) indicates irrigation requirements ranging from 5.5 to 8.7 inches per ton of alfalfa, not including contributions from the shallow water table beneath some of their instrumented, surface-irrigated fields. The amount of ground-water contribution was not determined in their work but, according to Tovey (1963, p. 32), surface-irrigation water requirements are less with the presence of a shallow water table. Data in Tovey's report (tables 30, 31, and 32) indicated that with a depth to water table less than 8 feet, a large part of the water consumed by alfalfa came directly from ground water.

In summary, the results of controlled experiments and computations based on the Blaney-Criddle method have a range in water consumption by alfalfa from 4.5 to 8.7 inches per ton. The distribution of water-consumptive values described above, suggest that from 5 to 6 inches of water is required to produce a ton of alfalfa under controlled conditions at Reno, and probably a similar amount is needed in Smith Valley. Water use in excess of this amount reportedly does not contribute to building plant tissue and may be (1) wasted, for example by excessive evaporation from the soil or as spray loss, or (2) recycled back to the ground-water reservoir by deep percolation. Also, it may or may not be economical to avoid use in excess of crop consumption.

RESULTS OF THIS STUDY

The amount of water used to sprinkler-irrigate the 1973 alfalfa crop on the Jessen Ranch is summarized in table 2. During the irrigation period approximately 42 inches of water was applied, of which precipitation was about 0.4 inch. The crop consisted of 13,609 bales of hay, or 848 tons. The average water application rate was 7.8 inches per ton. Of the four cuttings, the calculated water application rate was highest on the first and last cuttings. This is to be expected for the first cutting, because of the need to increase soil moisture after drying of soil during the previous winter. However, part of the high rate on the last cutting probably represents application of water in excess of plant requirements. Table 2 lists the fourth-cutting rate as 10.3 inches per ton of alfalfa. The two previous rates were 6.5 and 6.0 inches per ton. Assuming that a 6.0-inch rate would have been adequate for the fourth cutting, as shown on the following page, an adjusted water application for the entire season would have been 4.3 inches less, or 37.2 inches. This adjustment would lower the water-application rate to about 7 inches per ton.

COMPARISON WITH EXPERIMENTAL RESULTS

As described earlier, experimental studies show that the consumptive use for alfalfa in Smith Valley probably is about 5 to 6 inches per ton; 5.5 inches per ton is used here for comparison purposes. To adjust from experimental conditions to crop-production (field) conditions, provision has to be made for controlling the accumulation of salts in the soil by the addition of leaching water in excess of the consumptive requirements of the crop. On the basis of work by Fuller (1965) and Bernstein (1964), the leaching requirement for this irrigation operation is about 8 percent in excess of consumptive use. The total water requirement, as adjusted, would then be as follows:

	Inches per ton	Inches in 1973
Consumptive use under experimental conditions	5.5	29.7
Leaching need (8 percent)	.4	2.2
Total water requirement (rounded)	6.0	32

In summary, water was applied at a rate equal to 7.8 inches per ton of alfalfa. This was about 130 percent of the computed total water requirement for crop consumption and leaching. Using the adjusted application rate of 7.0 inches, the 1973 application rate would have been 120 percent of the computed requirement. Similar published case histories for other crops, other areas, and other methods of water application would provide an expanded base for decisions on the best use of Nevada's limited water resource.

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