Research Technical Completion Report

Project A-064-IDA

NON-POINT POLLUTION CONTROL FOR RANGELAND WINTERING

LIVESTOCK OPERATIONS (GROUND COVER)

by

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ABSTRACT

Cow-calf cattle operators in the Rocky Mountain West commonly graze their cattle on the range during spring, summer and fall. They hold their cattle in semi-confinement areas during the winter where they are normally fed hay. The holding area is often the land upon which the hay was grown during the summer. This land is often alongside a stream and considered a potential source of non-point pollution for that stream. This study was established to quantify the amount of pollutant loss from cow-calf winter feeding operations and to examine the possibility that one hay crop on the land may retain more pollutants from the runoff water than another.

Three ground cover (hay crop) treatments with two replications were established using an alfalfa and grass mixture. The mixtures were those used by ranchers in Owyhee County, Idaho, the location of the test plots. Grasses used with the alfalfa were brome, fescue and orchard grass. After the plots were established in 1979, cattle were placed on them each winter and removed each spring for the next three years. The plots were irrigated twice each year. Irrigation and runoff flows were monitored and water samples taken for analysis. There was no runoff from snowmelt or rainfall. The adjoining stream, Reynolds Creek, flooded during the spring of 1980 and washed out data collection facilities so no data were available for that year. The water samples were analyzed for amononia, nitrate, and Kjeldahl nitrogen, total phosphorus, orthophosphate, sodium, potassium, calcium, magnesium, and chloride. Other analysis included biological oxygen demand, chemical oxygen demand, dissolved oxygen, total organic carbon,

and suspended solids. Bacterial counts were made for fecal coliform, fecal streptococci and total coliforms. Mass balance calculations for each of these constituents were made based on the irrigation inflow, the runoff, and constituent concentrations. The results of these calculations quantify the pollutant loss from land wintering cattle.

An analysis of variance showed no significant difference between the ground cover treatment means for any constituent, although there was a trend toward better pollutant retention with the alfalfa and fescue mixture. The effect of the first versus the second irrigation event was also analyzed but no significant difference in the retention of pollutants was detected although there seemed to be a trend toward a greater retention during the second event.

CHAPTER I

INTRODUCTION AND OBJECTIVES

The quality of the water in the streams of Idaho and the Rocky Mountain Region is relevant and important to the people and the development of the region. The quality of this water is lowered when contaminates are added to the stream by natural streamflow, by dumping wastes into the stream as a "point source", and by drainage into the stream from a "non-point source". One non-point source is the drainage from cattle holding areas used by cow-calf cattle ranchers. The research reported is addressed to the evaluation of cattle management practices that might be used to maintain high water quality in Rocky Mountain streams. Specific objectives were:

1. To quantify pollutant losses in the surface runoff from land used for cattle wintering, and
2. To determine the relative effectiveness of three ground cover hay crops for the control of pollutants from cattle wintering areas.

An explanation of cow-calf type beef cattle ranches in the western United States will help understand the rational for this research. The majority of the ranches semi-confine their cattle during the winter and graze them from late spring to early fall. At the end of the grazing period, the animals are gathered and the calves weaned. The animals not marketed are transferred to the wintering area. The length of time the mature cows are kept in the semi-confinement areas varies from three to five months depending upon climate conditions and grazing allotments. Lot size and cattle density vary from ranch to ranch, and is influenced by numbers of cattle and physical limitations. During the grazing season, most of the semi-confinement areas are irrigated and used for hay crops. The major winter cattle feed is baled alfalfa or mixed species hay. This is generally fed from trucks or wagons and scattered on the ground. The water source is often a stream running through the semi-confinement area. Most ranchers plan for calving the cows while they are still in the wintering areas.

CHAPTER 2

FACILITIES AND PROCEDURES

The research plots were located in Owyhee County, Idaho within the Reynold Creek Research Watershed operated by the Northwest Watershed Research Center, Agricultural Research Service, U.S. Department of Agriculture. Approximately 5.2 ha of irrigated land on a privately-owned ranch was used to establish six plots as illustrated in Figure 1 and described in Table 1. Annual precipitation at the study site is approximately 250 mm. The plots were stocked as one unit with a stocking rate of approximately ten head per hectare, the stocking rate used by local ranchers. The calculated stocking rate is given in Table 2. The ground cover treatments for the plots were a mixture of alfalfa and brome, fescue, or orchard grass.

After the land was prepared and the ground cover plantings established with corrugated furrows for irrigation, turn-out ditches were constructed at the head of each plot and a collection ditch was constructed at the foot of each plot where needed. A measuring flume was placed in the irrigation ditch to determine the on-flow and in the collection (drainage) ditch to measure the runoff. A fence was installed around the 5.2 hectare which excluded the cattle from the adjoining creek and confined them to the plots. Well water was supplied to heated water troughs within the study area. Precipitation measurements were available from a USDA Weather Station alongside the plots.

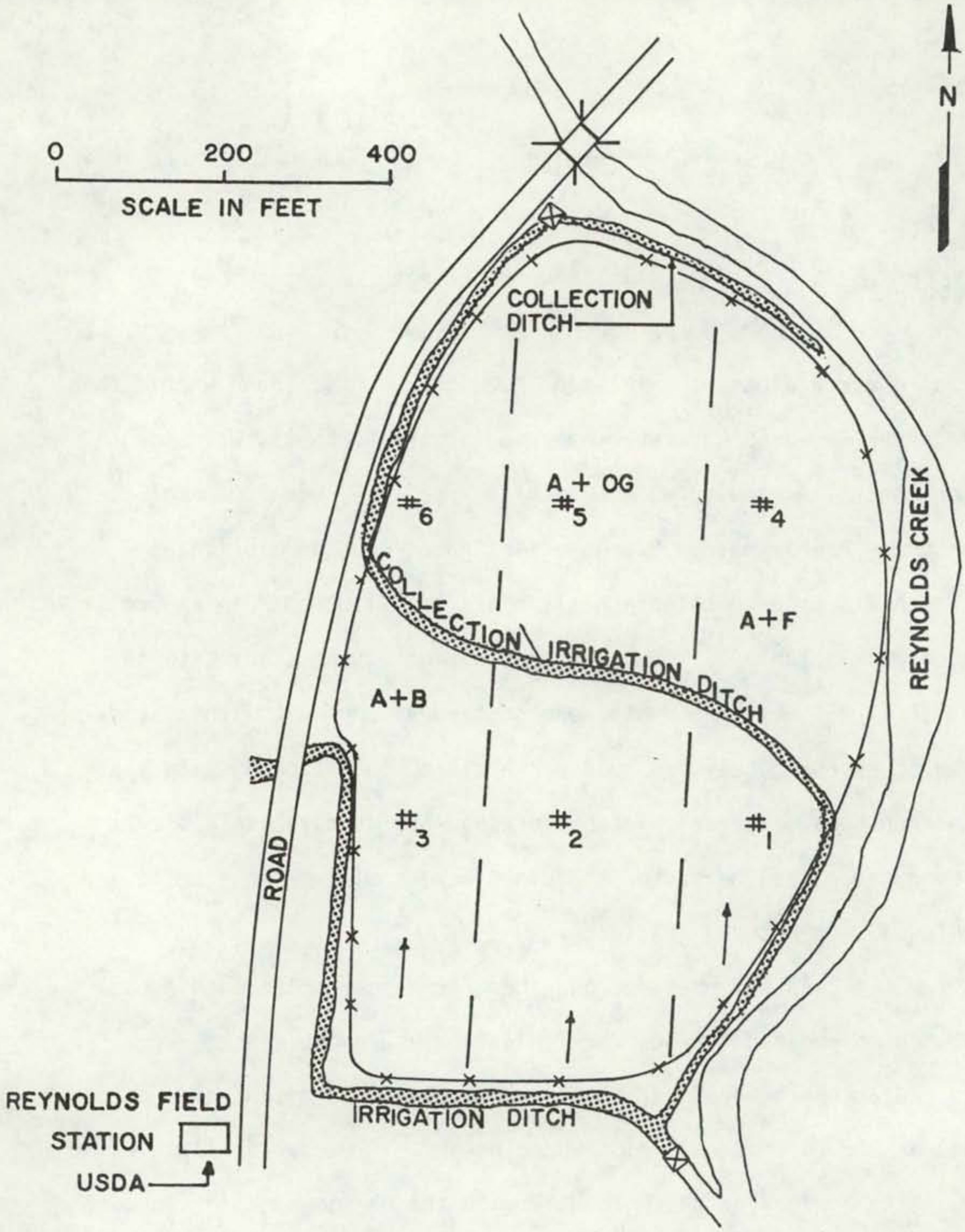

Figure 1. Arrangement of Plots Used for Wintering Cattle. The numbers are plot designations. The letters designate the treatment: A+B = alfalfa and brome; A+OG = alfalfa and orchard grass; A+F = alfalfa and fescue. The squares with crosses represent measuring flume locations.

Table 1. Discription of plots used for wintering cattle

Plot Number	Ground Cover Treatment	Area Hectare
1	Alfalfa & Fescue	0.97
2	Alfalfa & Orchard Grass	0.93
3	Alfalfa & Brome	0.93
4	Alfalfa & Fescue	0.81
5	Alfalfa & Orchard Grass	0.81
6	Alfalfa & Brome	0.77

Table 2. Stocking Rates, Dates of Irrigation Events and Cattle Use for the Plots*

	1979	1980**	1981
Stocking Rate	10.2 hd/ha	10.0 hd/ha	10.3 hd/ha
Event One	April 23-29	April 21-27	April 13-19
Event Two	May 14-20	May 5-10	May 4-10
Cattle Use	January 8 April 8	January 2 April 11	January 5- March 18

* All dates are inclusive.

**The plots were flooded by the adjoining creek thus collected data were not used.

Data collection from the research plots began during 1979 and continued for three years. Cattle were first placed on the plots January 8, 1979 and removed in the spring; a pattern similar to that followed by the neighboring ranchers. The cattle use dates for each year are noted in Table 2.

Sources of runoff were rainfall, snowmelt, and irrigation return flow. There was no runoff from snowmelt or rainfall during the three years. Precipitation occurring during an irrigation event was added to the irrigation water when calculating the water applied to the land. This situation occurred on two days, April 18 and 19, 1981. The calculations also accounted for the composition of the precipitation, as appropriate, when calculating pollutant losses from the land.

Because of a limited water supply, the plots were irrigated sequentially starting with the highest plot. Each plot was irrigated twice. The dates of irrigation for the three years are presented in Table 2. Surface irrigation using the corrugation method for distribution within the plots was used. The irrigation of one plot required approximately one day for a total time of approximately six days per event.

During each runoff event the water onto and off the plot was measured with a Parshall flume equipped with a continuous stage recorder. Samples from the irrigation streams were taken on a predetermined schedule: on entry to each plot, and at six hour intervals. The runoff water samples were collected at 15-minute intervals the first hour, 30-minute intervals the second hour, hourly the next six hours and at six hour intervals until the end of the event. Samples were analyzed for bacteria counts, chemical constituents, sediment concentrations and other characteristics. Water samples for chemical analyses were frozen the same day they were collected and later shipped to the University of Idaho Soil and Water Laboratory for analysis. The bacteria and sediment water samples were iced and taken to the Northwest Watershed Research Laboratory in Boise, ID. The bacteria samples were prepared and incubated within 24 hours of collection.

Results from the irrigation runoff were used to estimate the net loss of each constituent from each plot. These data were then evaluated by an analysis of variance to determine if the differences in losses between treatments and between events was significant. The amount of a constitutent in the incoming stream and the runoff stream was calculated by approximate integration for the time interval. The time interval for the integration was determined by the sampling schedule. The result gave the mass (or number) of the constituent entering or leaving the plot during the event. The difference between the mass (or number) leaving and entering the plot gave the net loss (or gain) of the constituent. This difference divided by the plot area determined the net loss (or gain) per unit area, the values upon which the analysis was based. The sum of the net losses from each event determined the annual pollutant loss. Because constituent losses are not continuous a more realistic loss rate during the time of flow might be expressed on a daily basis. For this daily rate, the net loss was divided by the elapsed time (in days) for the runoff event.

The data for bacterial count involved very large numbers. Other data, e.g. the chemical oxygen demand and suspended solid data, had a large range. In an effort to obtain a more meaningful statistical analysis, an analysis of variance was made on the logarithm of these values. Since some of the data were negative, the negative logarithm of the absolute value was used for the bacterial data and the other data was coded by adding an appropriate constant to force the data to a positive number.

For statistical analysis the plots were analyzed as a randomized complete block with split plots in time. True, randomization of the plots on the land was not attempted, rather a potential random arrangement was selected. This arrangement is shown in Figure 1. The "split plot in time" results from data being collected each year from the same plot. The constituent losses from these plots were measured for two events each year. The ground cover treatments were evaluated using the treatment-replicate interaction as the appropriate error term, i.e. the mean square for the treatmentreplicate interaction was used in the denominator to calculate the F-statistic. Figure 2 illustrates the skeleton analysis of variance table used to analyze each constituent.

Analysis of data from the first year (1979) indicated collection of some data was not needed. As a result no bacterial counts for fecal Streptococci were made and no analysis for chemical oxygen demand and chloride were made in subsequent years. The analysis of variance for these constituents was based on the data for one year, i.e. for two events.

As noted in Table 2 the experimental plots were flooded during 1980. The flood occurred during the first event and was caused by extremely heavy rainfall in the mountains feeding Reynolds Creek. The flood flushed the plots making measurements of constituent loss meaningless, since onflow and runoff could not be determined. Because of this all data for 1980 were excluded from the analysis of variance.

Figure 2. Skeleton Analysis of Variance Table to Analyze each Constituent

Source	Degrees of Freedom
Treatment	2
Replication	1
Treatment*Replication	2
Year	1
Event	1
Event*Year	1
Replication*Event	1
Treatment*Year	2
Treatment*Event	2
Replication*Year	1
Treatment*Event*Year	2

CHAPTER 3

RESULTS

Average losses of each constituent have been calculated and are presented in tabular form. The average net loss results have been divided into two categories with two units of measure. The two categories are the ground cover treatment and the event. The grouping by treatment is as expected from the stated objectives. The grouping by event was done because the first runoff event after the cattle were removed in the spring might produce a greater constituent loss than the second runoff event in the cycle. As explained earlier the two units of measure were the total (annual) net pollutant loss and the net pollutant loss rate on a per-day basis. The loss (gain) of each constituent from each plot was determined for each event (see the appendix). The numbers in the Tables 3 through 6 were obtained by averaging these values. The data in Table 3 show the average of the total loss from the three ground cover treatments for the entire time of each event by each constituent from land wintering cattle. The data in Table 4 show similar averages for the first and second events. Tables 5 and 6 are similar to Tables 3 and 4 but the data show the losses normalized to a one-day time period.

The analysis of variance showed no significant difference in any constituent among the ground cover treatments for either the total loss per event (Table 3) or the average loss rate (Table 5). Several of the constituents showed substantial difference between treatment means, e.g., TKN, chemical oxygen demand, fecal streptococci and total

Table 3. Average total loss of constituents from land wintering cattle for three ground covers.*

Constituent	Brome Mix	Fescue Mix	Orchard Grass Mix
		(Kilograms/Event - Hectare)	
Ammonia Nitrogen	0.19	0.16	0.29
Nitrate Nitrogen	0.15	0.28	0.66
TKN	0.06	0.18	2.00
Orthophosphate	0.49	0.07	0.40
Total Phosphorus	0.57	0.21	0.64
Sodium	-28.15	-37.51	-27.45
Potassium	6.72	- 0.90	6.71
Calcium	-31.74	-41.33	-29.13
Magnesium	-15.87	-20.22	-14.88
Chloride #	- 0.49	- 2.18	- 3.26
Biological Oxygen Demand	-20.91	-22.09	-19.76
Chemical Oxygen Demand #	3.68	16.04	24.76
Dissolved Oxygen **	-24.92	-26.36	-23.54
Total Organic Carbon	- 4.85	- 9.11	3.75
Suspended Solics	117.63	183.83	117.20
		(Counts/Event - Hectare)	
Fecal Coliform **	5.1×10^{9}	3.9×10^{9}	2.8×10^{9}
Fecal Streptococci ** #	1.6×10^{10}	1.4×10^{10}	2.6×10^{9}
Total Coliform **	2.5×10^{12}	-1.3×10^{11}	6.2×10^{12}

* An analysis of variance showed no significant difference between treatment averages. A minus sign means there was more constituent in the total volume of irrigation water than in the runoff, thus a net gain of the constituent.

** The implication of these results may be confounding; see text, "results".

\# Based on 1979 data only.

Table 4. Average total loss of constituents from land wintering cattle for two irrigation events.*

Constituent	Event 1	Event 2
	(Kilograms/Event - Hectare)	
Ammonia Nitrogen	0.34	0.09
Nitrate Nitrogen	0.19	0.54
TKN	1.54	- 0.04
Orthophosphate	0.26	0.39
Total Phosphorus	0.49	0.45
Sodium	-29,79	-32.28
Potassium	3.99	4.36
Calcium	-30.06	-35.07
Magnesium	-16.09	-17.89
Chloride #	- 2.90	- 1.05
Biological Oxygen Demand	-17.54	-24.30
Chemical Oxygen Demand #	24.97	4.68
Dissolved Oxygen **	-21.28	-28.60
Total Organic Carbon	- 1.87	- 4.94
Suspended Solids	241.83	37.27
	(Counts/Event - Hectare)	
Fecal Coliform **	3.5×10^9	-7.6×10^9
Fecal Streptococci ** #	2.4×10^{10}	-2.2×10^9
Total Coliform **	2.9×10^{12}	2.7×10^{12}

* An analysis of variance showed no significant difference between event averages. See Table 2 for dates of each event. A minus sign means there was more constituent in the total volume of irrigaiton water than in the runoff, thus a net gain of the constituent.

** The implication of these results may be confounding; see text, "results".

Based on 1979 data only.

Table 5. Average loss rate of constituents from land wintering cattle for three ground covers.*

Constituent	Brome Mix	Fescue Mix	Orchard Grass Mix
	(Kilograms/Event-day - Hectare)		
Ammonia Nitrogen	0.17	0.16	0.29
Nitrate Nitrogen	0.12	0.27	0.65
TKN	0.01	0.18	1.96
Orthophosphate	0.46	0.07	0.39
Total Phosphorus	0.54	0.20	0.62
Sodium	-27.10	-35.78	-27.28
Potassium	6.29	- 0.89	6.54
Calcium	-30.56	-39.39	-28.97
Magnesium	-15.26	-19.28	-14.76
Chloride #	- 0.52	- 2.06	- 3.22
Biological Oxygen Demand	-20.25	-21.02	-19.38
Chemical Oxygen Demand #	2.83	14.40	23.86
Dissolved Oxygen **	-24.02	-25.16	-23.22
Total Organic Carbon	- 4.76	- 8.67	3.55
Suspended Solics	117.37	173.86	111.95
	(Counts/Event-day - Hectare)		
Fecal Coliform **	6.0×10^9	3.8×10^9	2.8×10^9
Fecal Streptococci ** #	1.5×10^{10}	1.3×10^{10}	2.7×10^9
Total Coliform **	2.4×10^{12}	-1.3×10^{11}	6.1×10^{12}

* An analysis of variance showed no significant difference between treatment averages. A minus sign means there was more constituent in the total volume of irrigation water than in the runoff, thus a net gain of the constituent.

** The implication of these results may be confounding; see text "results".

\# Based on 1979 data only.

Table 6. Average loss rate of constituents from land wintering cattle for two irrigation events.*

Constituent	Event 1	Event 2
	(Kilograms/Event-day - Hectare)	
Ammonia Nitrogen	0.33	0.08
Nitrate Nitrogen	0.18	0.51
TKN	1.47	- 0.03
Orthophosphate	0.25	0.37
Total Phosphorus	0.47	0.44
Sodium	-29.21	-30.89
Potassium	3.78	4.18
Calcium	-32.45	-33.50
Magnesium	-15.76	-17.10
Chloride #	- 2.86	- 1.01
Biological Oxygen Demand	-17.07	-23.37
Chemical Oxygen Demand #	23.37	4.03
Dissolved Oxygen **	-20.86	-27.40
Total Organic Carbon	- 2.04	- 4.55
Suspended Solids	230.73	38.05
	(Counts/Event-day - Hectare)	
Fecal Coliform **	3.4×10^{9}	-8.0×10^{9}
Fecal Streptococci ** #	2.3×10^{10}	-2.1×10^{9}
Total Coliform **	2.9×10^{12}	2.7×10^{12}

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* An analysis of variance showed no significant difference between event averages. See Table 2 for dates of each event. A minus sign means there was more constituent in the total volume of irrigaiton water than in the runoff, thus a net gain of the constituent.

** The implication of these results may be confounding; see text, "results".

\# Based on 1979 data only.

coliforms, but variability in the measured values caused lack of significance. Further review of Table 3 or 4 shows a trend for less constituent loss from the fescue mix ground cover than the others for most constituents. The exceptions are nitrate nitrogen, TKN, chloride, chemical oxygen demand, fecal coliform, and fecal streptococci.

The analysis of variance showed no significant difference between the first and second event for any constituent. This was true for both the total loss per event (Table 5) and average loss rate (Table 6). A review of Table 5 or 6 shows a trend of less loss of constituent during the second event for all constituents but four. The four constituents with average loss smaller for the first event are nitrate nitrogen, orthophosphate, potassium and chloride. Constituents with a much larger average for event one than event two include suspend solids, fecal coliform and fecal streptococci.

When reviewing the data presented here the following factors need special consideration: source and quantity of runoff, the implication of negative numbers, and the uniqueness of some constituents.

The data and analysis involved runoff during irrigation events only. There was no runoff from snowmelt during the three year study period. For the two years included in the study, runoff from rainfall was limited to that which occurred during an irrigation period. The rainfall on April 18 and 19, 1981 contributed approximately 1.4 cubic meters of water to the fields. During the same time the irrigation flow contributed approximately 1000 cubic meters of water to the field. Since the rainfall was only about 0.1 percent of the water applied to the field, it was considered negligible. This being the case, the pollutant losses were controlled to a great extent by the management of the irrigation water. If there had been no runoff (irrigation return flow), there would have been no pollutant loss.

A negative number implies there was a net constituent gain, i.e. more material was added by the irrigation water than left the land in the runoff. Although the concentration of a constituent may be lower in the irrigation water than the runoff, the volume of irrigation water put on the field is large compared to the volume of runoff water. Also, there was the possibility that the plants and soil removed more of some constituents from the irrigation water than was picked up by the water as it moved across the field. For dissolved oxygen and the bacteria, there were other possibilities. The dissolved oxygen values could have been influenced by the water/air interface and the bacteria measurements could have been influenced by die-off or multiplication of the organism as the water flowed across the field.

CHAPTER 4

CONCLUSIONS

The material presented in Tables 3 through 6 and in the appendix quantify pollutant losses in the surface runoff of irrigation water from land used to winter cattle. If these data were to be used for broader estimates of pollutant losses from cattle wintering operations, they should be limited to situations involving runoff from irrigation water.

The amount of pollutant loss through irrigation return flow from land wintering cattle seems to be small. For example, Dixon et al. (1977) gave a range of values for annual loss of nitrogen and phosphorus from beef cattle feedlots. For total nitrogen the range was 100 to 1600 kg/ha which is in contrast to the total for TKN of 1.50 kg/ha (Table 4, Event 1 + Event 2) in this study. For total phosphorus the range for the feedlots was 9 to 620 kg/ha and the sum from Table 4 for total phosphorus was 0.94 kg/ha. For these constituents the pollutant loss from cattle wintering operations seems quite small.

The difference in effectiveness of the three ground covers, alfalfa and brome grass, alfalfa and fescue grass, and alfalfa and orchard grass, for controlling pollutant loss was negligible. An analysis of variance did not find one ground cover significantly better at controling pollutant loss than another ground cover. There did seem to be a trend that the alfalfa and fescue mixture had a lower pollutant loss for most of the constituents.

The first runoff after cattle were removed from the land in the spring did not have significantly more pollutant loss than the second runoff event. The data did indicate there was a trend for more loss during the first event for most constituents.

REFERENCES AND BIBLIOGRAPHY

Dixon, J.E., G.R. Stephenson, A.J. Lingg, D.V. Naylor, and D.D. Hinman. 1977. Nonpoint pollution control for wintering range cattle. Presentation for June 26-29 meeting at Raleigh, N.C., ASAE Paper No. 77-4049, ASAE, St. Joseph, Michigan 49085.

__________. 1980. Stocking rate influence upon pollutant losses from land wintering rangeland cattle: a preliminary study. Proceedings 4th International Symposium on Livestock Wastes. April 15-17, Amarillo, Texas. pp. 261-265.

__________. 1981. Livestock pollutants transported from three ground covers. Presentation for June 21-24 meeting at Orlando, Florida, ASAE Paper No. 81-2001, ASAE, St. Joseph, Michigan 48085.

__________. 1981. Cattle wintering stocking rate and water quality. Presentation for December 15-18 meeting at Chicago, Illinois, ASAE Paper No. 81-2584, ASAE, St. Joseph, Michigan 48085.

APPENDIX

Tables A1 through A8 present the data upon which the statistical analyses were based. The mass (number for bacterial data) of each constituent entering the irrigation water, leaving in the runoff, and the net mass leaving each plot is shown. The time duration for each plot irrigation is also shown. The plots were sequentially irrigated in the order shown, i.e. plot No. 3 was irrigated first, plot No. 2 second, etc. Averages were taken of the net mass values to obtain the values in Tables 3 and 4. Another set of values similar to the net mass values were calculated by dividing the net mass value by the event time. Those quotients were used to obtain the averages shown in Tables 5 and 6.

As noted earlier data for the constituents, chloride, C.O.D., and fecal streptcoccus were collected for 1979 only. Abbreviations in the tables are as follows:

TKN -- total Kjeldahl nitrogen

ORTHO-P -- orthophosphate

TOTAL-P -- total phosphorus

B.O.D. -- biological oxygen demand (5-day)

C.O.D. -- chemical oxygen demand

D.O. -- dissolved oxygen

T.O.C. -- total organic carbon

TABLE A1. THE MASS OF EACH CHEMICAL CONSTITUENT ENTERING BY IRRIGATION, LEAVING BY RUNOFF AND THE NET LOSS (OR GAIN) FOR EACH PLOT FOR EVENT NUMBER 1 DURING 1979. THE DURATION OF THE EVENT IS ALSO GIVEN AND WAS USED TO CALCULATE THE NET LOSS (GAIN) RATE.

CONSTITUENT	PLOT NO.	EVENT TIME HR.	IRRIG. MASS PER EVENT KG/HA	RUNOFF MASS PER EVENT KG/HA	NET MASS PER EVENT KG/HA
AMMONIA					
	3	24.25	0.8148E-01	0.6652E 00	0.5837E 00
	2	22.34	0.4849E-01	0.4779E 00	0.4294E 00
	1	25.50	0.7895E-01	0.3029E 00	0.2240E 00
	4	24.42	0.4678E-01	0.3725E 00	0.3257E 00
	5	21.92	0.8625E-01	0.5435E 00	0.4573E 00
	6	23.75	0.6060E-01	0.4307E 00	0.3701E 00
NITRATE					
	3	24.25	0.3972E 00	0.6612E 00	0.2640E 00
	2	22.34	0.2329E 00	0.4919E 00	0.2590E 00
	I	25.50	0.3944E 00	0.4153E 00	0.2096E-01
	4	24.42	0.6432E 00	0.4022E 00	-0.2410E 00
	5	21.92	0.2803E 00	0.4947E 00	0.2144E 00
	6	23.75	0.3687E 00	0.5697E 00	0.2010E 00
T K N					
	3	24.25	0.2037E-01	0.2877E 01	0.2856E 01
	2	22.34	0.6613E-01	0.1865E 01	0.1799E 01
	1	25.51	0.1472E 00	0.1446E 01	0.1299E 01
	4	24.42	0.3625E 00	0.2527E 01	0.2165E 01
	5	21.92	0.5498E 00	0.2452E 01	0.1902E 01
	6	23.77	0.1215E 01	0.1937E 01	0.7227E 00
ORTHO-P					
	3	24.25	0.6111E-01	0.5090E 00	0.4479E 00
	2	22.35	0.1045E 00	0.3203E 00	0.2159E 00
	1	25.50	0.7135E-01	0.2767E 00	0.2054E 00
	4	24.42	0.1052E 00	0.3119E 00	0.2066E 00
	5	21.92	0.8625E-01	0.3329E 00	0.2467E 00
	6	23.75	0.7224E-01	0.3630E 00	0.2908E 00
TOTAL-P					
	3	24.24	0.1731E 00	0.8356E 00	0.6624E 00
	2	22.34	0.1441E 00	0.4828E 00	0.3387E 00
	1	25.50	0.2175E 00	0.4299E 00	0.2124E 00
	4	24.42	0.2105E 00	0.1072E 01	0.8615E 00
	5	21.92	0.8625E-01	0.6433E 00	0.5570E 00
	6	23.75	0.2236E 00	0.8163E 00	0.5927E 00
SODIUM					
	3	24.25	0.1243E 02	0.1015E 02	-0.2274E 01
	2	22.34	0.1169E 02	0.6272E 01	-0.5420E 01
	1	25.51	0.1287E 02	0.6232E 01	-0.6640E 01
	4	24.43	0.1263E 02	0.5590E 01	-0.7039E 01
	5	21.92	0.8948E 01	0.5670E 01	-0.3279E 01
	6	23.76	0.1096E 02	0.6517E 01	-0.4443E 01
POTASSIUM					
	3	24.25	0.2037E 01	0.1318E 02	0.1114E 02
	2	22.33	0.2574E 01	0.7910E 01	0.5336E 01
	1	25.50	0.3114E 01	0.7359E 01	0.4245E 01
	4	24.42	0.3625E 01	0.7186E 01	0.3561E 01
	5	21.92	0.1725E 01	0.8122E 01	0.6397E 01
	6	23.75	0.2376E 01	0.9238E 01	0.6861E 01
CALCIUM					
	3	24.24	0.1120E 02	0.9111E 01	-0.2092E 01
	2	22.34	0.1336E 02	0.8556E 01	-0.4804E 01
	1	25.49	0.1689E 02	0.7029E 01	-0.9863E 01
	4	24.42	0.1520E 02	0.8113E 01	-0.7089E 01
	5	21.93	0.1186E 02	0.7523E 01	-0.4336E 01
	6	23.76	0.1314E 02	0.7733E 01	-0.5403E 01
MAGNESIUM					
	3	24.25	0.6518E 01	0.4003E 01	-0.2515E 01
	2	22.34	0.6321E 01	0.3530E 01	-0.2791E 01
	1	25.50	0.7370E 01	0.3044E 01	-0.4326E 01
	4	24.42	0.7601E 01	0.3022E 01	-0.4579E 01
	5	21.92	0.5067E 01	0.2777E 01	-0.2291E 01
	6	23.75	0.6195E 01	0.3103E 01	-0.3092E 01
CHLORIDE					
	3	24.25	0.8453E 01	0.1029E 02	0.1840E 01
	2	22.34	0.7954E 01	0.3860E 01	-0.4094E 01
	1	25.50	0.2969E 01	0.4278E 01	0.1310E 01
	4	24.43	0.1088E 02	0.3941E 01	-0.6934E 01
	5	21.92	0.7223E 01	0.3168E 01	-0.4055E 01
	6	23.75	0.7535E 01	0.2071E 01	-0.5464E 01

TABLE A2. THE MASS (NUMBER*) OF EACH OTHER CONSTITUENT ENTERING BY IRRIGATION, LEAVING BY RUNOFF AND THE NET LOSS (OR GAIN) FOR EACH PLOT FOR EVENT NUMBER 1 DURING 1979. THE DURATION OF THE EVENT IS ALSO GIVEN AND WAS USED TO CALCULATE THE NET LOSS (GAIN) RATE.

CONSTITUENT	PLOT NO.	EVENT TIME HR.	IRRIG. MASS PER EVENT KG/HA	RUNOFF MASS PER EVENT KG/HA	NET MASS PER EVENT KG/HA
FECAL COLIFORM*					
	3	24.25	0.5092E 10	0.1037E 11	0.5273E 10
	2	22.34	0.1888E 11	0.7983E 10	-0.1090E 11
	1	25.50	0.1498E 10	0.4694E 10	0.3196E 10
	4	24.42	0.7952E 09	0.7887E 10	0.7092E 10
	5	21.92	0.7008E 10	0.2299E 11	0.1598E 11
	6	23.74	0.1357E 10	0.4953E 11	0.4818E 11
FECAL STREPTOCOCCUS*					
	3	24.25	0.5092E 09	0.5758E 11	0.5707E 11
	2	22.35	0.9526E 07	0.7435E 10	0.7426E 10
	1	25.50	0.2703E 09	0.3620E 11	0.3593E 11
	4	24.42	0.4678E 09	0.1699E 11	0.1652E 11
	5	21.92	0.5391E 09	0.5621E 10	0.5082E 10
	6	23.75	0.2477E 09	0.2299E 11	0.2274E 11
TOTAL COLIFORM*					
	3	24.25	0.2546E 11	0.9740E 11	0.7194E 11
	2	22.34	0.1226E 12	0.2033E 11	-0.1023E 12
	1	25.50	0.5854E 10	0.1029E 11	0.4432E 10
	4	24.42	0.5847E 09	0.2749E 11	0.2691E 11
	5	21.91	0.1509E 11	0.1648E 12	0.1497E 12
	6	23.75	0.2092E 10	0.8788E 11	0.8579E 11
B. O. D.					
	3	23.75	0.0	0.2174E 01	0.2174E 01
	2	23.75	0.0	0.1411E 01	0.1411E 01
	1	23.75	0.0	0.7158E 00	0.7158E 00
	4	23.75	0.0	0.2820E 01	0.2820E 01
	5	23.75	0.0	0.3095E 01	0.3095E 01
	6	23.75	0.0	0.9427E 00	0.9427E 00
C. O. D.					
	3	24.25	0.9981E 01	0.4292E 02	0.3294E 02
	2	22.34	0.1625E 02	0.2309E 02	0.6842E 01
	1	25.50	0.5873E 00	0.7601E 02	0.7542E 02
	4	24.42	0.4210E 01	0.2754E 02	0.2333E 02
	5	21.92	0.2156E 01	0.2953E 02	0.2738E 02
	6	23.75	0.5561E 02	0.3950E 02	-0.1611E 02
D. O.					
	3	23.75	0.0	0.3506E 01	0.3506E 01
	2	23.75	0.0	0.2640E 01	0.2640E 01
	1	23.92	0.8007E 01	0.3310E 01	-0.4697E 01
	4	24.42	0.8303E 01	0.4196E 01	-0.4107E 01
	5	21.91	0.9487E 01	0.3725E 01	-0.5762E 01
	6	23.76	0.1074E 02	0.3228E 01	-0.7514E 01
T. O. C.					
	3	24.25	0.9064E 01	0.1643E 02	0.7363E 01
	2	22.34	0.8248E 01	0.1181E 02	0.3565E 01
	1	25.50	0.5798E 01	0.9739E 01	0.3941E 01
	4	24.42	0.6666E 01	0.1448E 02	0.7813E 01
	5	21.92	0.6145E 01	0.1177E 02	0.5625E 01
	6	23.75	0.1042E 02	0.9868E 01	-0.5484E 00
SUSPENDED SOLIDS					
	3	24.25	0.3972E 02	0.1416E 03	0.1018E 03
	2	22.34	0.4818E 02	0.3780E 02	-0.1037E 02
	1	25.49	0.2699E 01	0.8473E 02	0.8203E 02
	4	24.42	0.1871E 02	0.9350E 03	0.9163E 03
	5	21.94	0.1084E 03	0.8629E 02	-0.2206E 02
	6	23.75	0.2980E 01	0.9670E 02	0.9372E 02

* THE RESULTS FOR FECAL COLIFORM, FECAL STREPTOCOCCUS AND TOTAL COLIFORM ARE GIVEN AS NUMBER OF BACTERIA PER HECTARE RATHER THAN THE LISTED UNITS.

TABLE A3. THE MASS OF EACH CHEMICAL CONSTITUENT ENTERING BY IRRIGATION, LEAVING BY RUNOFF AND THE NET LOSS (OR GAIN) FOR EACH PLOT FOR EVENT NUMBER 2 DURING 1979. THE DURATION OF THE EVENT IS ALSO GIVEN AND WAS USED TO CALCULATE THE NET LOSS (GAIN) RATE.

CONSTITUENT	PLOT NO.	EVENT TIME HR.	IRRIG. MASS PER EVENT KG/HA	RUNOFF MASS PER EVENT KG/HA	NET MASS PER EVENT KG/HA
AMMONIA					
	3	24.26	0.1015E-01	0.1834E 00	0.1732E 00
	2	23.51	0.2903E-01	0.1343E 00	0.1053E 00
	1	23.50	0.4662E-01	0.6919E-01	0.2257E-01
	4	23.00	0.3344E-01	0.6722E-01	0.3378E-01
	5	23.50	0.6709E-01	0.1162E 00	0.4912E-01
	6	23.75	0.4832E-01	0.8170E-01	0.3338E-01
NITRATE					
	3	24.25	0.5074E-01	0.3480E 00	0.2973E 00
	2	23.50	0.4856E-01	0.3322E 00	0.2836E 00
	1	23.50	0.9562E-02	0.3218E 00	0.3123E 00
	4	23.00	0.4196E 00	0.3620E 00	-0.5752E-01
	5	23.50	0.3843E 00	0.4030E 00	0.1871E-01
	6	23.75	0.2077E 00	0.5335E 00	0.3258E 00
T K N					
	3	24.25	0.6495E 00	0.1462E 01	0.8121E 00
	2	23.50	0.2450E 00	0.9109E 00	0.6659E 00
	1	23.50	0.4845E 00	0.6586E 00	0.1741E 00
	4	23.00	0.7541E 00	0.1249E 01	0.4949E 00
	5	23.50	0.9222E 00	0.1029E 01	0.1073E 00
	6	23.75	0.2675E 00	0.9322E 00	0.6647E 00
ORTHO-P					
	3	24.26	0.1015E 00	0.3013E 00	0.1998E 00
	2	23.49	0.1068E 00	0.1902E 00	0.8341E-01
	1	23.50	0.6563E-01	0.2105E 00	0.1449E 00
	4	23.00	0.1881E 00	0.2267E 00	0.3854E-01
	5	23.50	0.5874E-01	0.2003E 00	0.1416E 00
	6	23.75	0.1414E 00	0.2689E 00	0.1275E 00
TOTAL-P					
	3	24.25	0.2233E 00	0.3522E 00	0.1289E 00
	2	23.50	0.1364E 00	0.2869E 00	0.1504E 00
	1	23.50	0.1587E 00	0.2063E 00	0.4755E-01
	4	23.01	0.2109E 00	0.4366E 00	0.2258E 00
	5	23.50	0.2143E 00	0.2883E 00	0.7398E-01
	6	23.75	0.3552E 00	0.3743E 00	0.1906E-01
SODIUM					
	3	24.25	0.7672E 01	0.5712E 01	-0.1960E 01
	2	23.50	0.7343E 01	0.4176E 01	-0.3167E 01
	1	23.50	0.7734E 01	0.3321E 01	-0.4413E 01
	4	23.00	0.8687E 01	0.5031E 01	-0.3656E 01
	5	23.50	0.6848E 01	0.4048E 01	-0.2799E 01
	6	23.75	0.9826E 01	0.5332E 01	-0.4495E 01
POTASSIUM					
	3	24.25	0.2324E 01	0.7451E 01	0.5127E 01
	2	23.49	0.2224E 01	0.4839E 01	0.2615E 01
	1	23.51	0.2196E 01	0.3691E 01	0.1495E 01
	4	23.00	0.3393E 01	0.4466E 01	0.1072E 01
	5	23.50	0.3019E 01	0.4982E 01	0.1963E 01
	6	23.75	0.3270E 01	0.5251E 01	0.1981E 01
CALCIUM					
	3	24.25	0.1167E 02	0.7287E 01	-0.4384E 01
	2	23.49	0.1020E 02	0.6864E 01	-0.3340E 01
	1	23.49	0.1065E 02	0.6129E 01	-0.4519E 01
	4	23.00	0.1332E 02	0.7313E 01	-0.6009E 01
	5	23.49	0.1065E 02	0.7188E 01	-0.3465E 01
	6	23.76	0.1088E 02	0.6920E 01	-0.3955E 01
MAGNESIUM					
	3	24.25	0.5582E 01	0.3691E 01	-0.1890E 01
	2	23.50	0.5130E 01	0.3055E 01	-0.2075E 01
	1	23.50	0.4210E 01	0.2556E 01	-0.1654E 01
	4	23.00	0.5571E 01	0.3144E 01	-0.2427E 01
	5	23.50	0.4709E 01	0.3258E 01	-0.1451E 01
	6	23.75	0.3719E 01	0.2566E 01	-0.1153E 01
CHLORIDE					
	3	24.26	0.1015E-02	0.1156E 01	0.1155E 01
	2	23.50	0.4374E 01	0.1085E 01	-0.3290E 01
	1	23.50	0.2682E 01	0.8664E 00	-0.1815E 01
	4	23.00	0.2712E 01	0.1439E 01	-0.1273E 01
	5	23.49	0.2364E 01	0.7549E 00	-0.1609E 01
	6	23.75	0.5854E-01	0.5712E 00	0.5126E 00

TABLE A4. THE MASS (NUMBER*) OF EACH OTHER CONSTITUENT ENTERING BY IRRIGATION, LEAVING BY RUNOFF AND THE NET LOSS (OR GAIN) FOR EACH PLOT FOR EVENT NUMBER 2 DURING 1979. THE DURATION OF THE EVENT IS ALSO GIVEN AND WAS USED TO CALCULATE THE NET LOSS (GAIN) RATE.

CONSTITUENT	PLOT NO.	EVENT TIME HR.	IRRIG. MASS PER EVENT KG/HA	RUNOFF MASS PER EVENT KG/HA	NET MASS PER EVENT KG/HA
FECAL COLIFORM*					
	3	24.25	0.4059E 09	0.8031E 09	0.3972E 09
	2	23.51	0.1568E 09	0.1313E 10	0.1157E 10
	1	23.50	0.1495E 09	0.1058E 10	0.9080E 09
	4	23.00	0.5229E 10	0.9240E 09	-0.4305E 10
	5	23.50	0.9219E 09	0.3055E 10	0.2133E 10
	6	23.75	0.2196E 08	0.7815E 09	0.7596E 09
FECAL STREPTOCOCCUS*					
	3	24.25	0.5277E 09	0.1222E 10	0.6941E 09
	2	23.50	0.9299E 09	0.2359E 10	0.1429E 10
	1	23.50	0.8971E 09	0.2837E 10	0.1940E 10
	4	23.00	0.3391E 10	0.5232E 10	0.1841E 10
	5	23.50	0.9385E 10	0.5933E 10	-0.3451E 10
	6	23.75	0.2076E 11	0.4813E 10	-0.1595E 11
TOTAL COLIFORM*					
	3	24.26	0.1218E 09	0.3811E 10	0.3689E 10
	2	23.50	0.1552E 09	0.1600E 10	0.1445E 10
	1	23.50	0.1495E 09	0.2029E 10	0.1880E 10
	4	23.00	0.6075E 10	0.3363E 10	-0.2712E 10
	5	23.49	0.3811E 10	0.7098E 10	0.3287E 10
	6	23.75	0.8027E 10	0.3570E 10	-0.4457E 10
B. O. D.					
	3	23.75	0.0	0.4701E-01	0.4701E-01
	2	23.75	0.0	0.7421E 00	0.7421E 00
	1	23.75	0.0	0.1963E 01	0.1963E 01
	4	23.75	0.0	0.2132E 00	0.2132E 00
	5	23.75	0.0	0.6351E 00	0.6351E 00
	6	23.75	0.0	0.1917E 01	0.1917E 01
C. O. D.					
	3	24.25	0.5987E 01	0.3401E 02	0.2802E 02
	2	23.50	0.3355E-01	0.2583E 02	0.2580E 02
	1	23.50	0.3902E 01	0.2034E 02	0.1644E 02
	4	23.00	0.6406E 02	0.1300E 02	-0.5105E 02
	5	23.50	0.3970E 01	0.4297E 02	0.3900E 02
	6	23.75	0.3509E 02	0.4963E 01	-0.3013E 02
D. O.					
	3	24.25	0.5480E 01	0.2725E 01	-0.2755E 01
	2	23.50	0.5824E 01	0.2989E 01	-0.2835E 01
	1	23.50	0.6536E 01	0.2879E 01	-0.3657E 01
	4	23.00	0.3814E 01	0.4059E 01	0.2452E 00
	5	23.51	0.1058E 02	0.4081E 01	-0.6495E 01
	6	23.75	0.7258E 01	0.4020E 01	-0.3238E 01
T. O. C.					
	3	24.25	0.7307E 01	0.1078E 02	0.3469E 01
	2	23.50	0.7283E 01	0.7248E 01	-0.3465E-01
	1	23.50	0.7009E 01	0.7018E 01	0.9263E-02
	4	23.01	0.1065E 02	0.1127E 02	0.6192E 00
	5	23.50	0.9166E 01	0.9160E 01	-0.5336E-02
	6	23.74	0.2672E 01	0.6556E 01	0.3883E 01
SUSPENDED SOLIDS					
	3	24.25	0.1461E 02	0.4631E 02	0.3170E 02
	2	23.51	0.2442E 02	0.1630E 02	-0.8113E 01
	1	23.50	0.3916E 02	0.1228E 02	-0.2688E 02
	4	23.00	0.7761E 02	0.1036E 03	0.2600E 02
	5	23.50	0.3783E 02	0.7226E 02	0.3443E 02
	6	23.75	0.3667E 03	0.1186E 02	-0.3548E 03

* THE RESULTS FOR FECAL COLIFORM, FECAL STREPTOCOCCUS AND TOTAL COLIFORM ARE GIVEN AS NUMBER OF BACTERIA PER HECTARE RATHER THAN THE LISTED UNITS.

TABLE A5. THE MASS OF EACH CHEMICAL CONSTITUENT ENTERING BY IRRIGATION, LEAVING BY RUNOFF AND THE NET LOSS (OR GAIN) FOR EACH PLOT FOR EVENT NUMBER 1 DURING 1981. THE DURATION OF THE EVENT IS ALSO GIVEN AND WAS USED TO CALCULATE THE NET LOSS (GAIN) RATE.

CONSTITUENT	PLOT NO.	EVENT TIME HR.	IRRIG. MASS PER EVENT KG/HA	RUNOFF MASS PER EVENT KG/HA	NET MASS PER EVENT KG/HA
AMMONIA					
	3	23.50	0.9757E-01	0.2698E 00	0.1722E 00
	2	24.83	0.7570E-01	0.4852E 00	0.4095E 00
	1	24.00	0.8003E-01	0.2317E 00	0.1517E 00
	4	23.98	0.1159E 00	0.7834E 00	0.6676E 00
	5	23.00	0.1152E 00	0.4494E 00	0.3342E 00
	6	23.51	0.1095E 00	0.7318E-01	-0.3650E-01
NITRATE					
	3	23.51	0.2098E 01	0.1676E 01	-0.4214E 00
	2	24.83	0.7263E 00	0.2142E 01	0.1415E 01
	1	24.00	0.3616E 00	0.3253E 00	-0.3633E-01
	4	23.98	0.1259E 00	0.2238E 01	0.2112E 01
	5	23.00	0.1152E 00	0.7983E 00	0.6831E 00
	6	23.50	0.2910E 01	0.7077E 00	-0.2203E 01
T K N					
	3	23.49	0.1951E 01	0.4023E 01	0.2071E 01
	2	24.83	0.7630E 00	0.5150E 01	0.4387E 01
	1	24.00	0.8003E 00	0.1204E 01	0.4032E 00
	4	23.98	0.2289E 01	0.5277E 01	0.2989E 01
	5	23.00	0.2304E 01	0.2090E 01	-0.2139E 00
	6	23.51	0.4227E 01	0.2285E 01	-0.1942E 01
ORTHO-P					
	3	23.50	0.5854E 00	0.1353E 01	0.7679E 00
	2	24.83	0.2664E 00	0.7605E 00	0.4941E 00
	1	24.00	0.3200E 00	0.2979E 00	-0.2214E-01
	4	23.98	0.5765E 00	0.8774E 00	0.3009E 00
	5	23.00	0.5759E 00	0.6007E 00	0.2479E-01
	6	23.50	0.7002E 00	0.5825E 00	-0.1177E 00
TOTAL-P					
	3	23.50	0.9757E 00	0.2163E 01	0.1187E 01
	2	24.83	0.5317E 00	0.1825E 01	0.1293E 01
	1	24.00	0.4805E 00	0.4075E 00	-0.7303E-01
	4	23.98	0.9777E 00	0.1639E 01	0.6610E 00
	5	22.99	0.9790E 00	0.7057E 00	-0.2733E 00
	6	23.50	0.1083E 01	0.1002E 01	-0.8162E-01
SODIUM					
	3	23.50	0.9709E 02	0.4501E 02	-0.5208E 02
	2	24.83	0.6405E 02	0.4920E 02	-0.1486E 02
	1	24.00	0.7799E 02	0.1448E 02	-0.6352E 02
	4	23.98	0.9206E 02	0.1870E 02	-0.7336E 02
	5	23.00	0.9099E 02	0.1022E 02	-0.8078E 02
	6	23.50	0.6052E 02	0.1670E 02	-0.4382E 02
POTASSIUM					
	3	23.50	0.2342E 02	0.3047E 02	0.7054E 01
	2	24.83	0.1261E 02	0.2699E 02	0.1438E 02
	1	24.00	0.1321E 02	0.8608E 01	-0.4598E 01
	4	23.99	0.1912E 02	0.2466E 02	0.5540E 01
	5	23.00	0.1900E 02	0.1452E 02	-0.4484E 01
	6	23.50	0.1959E 02	0.1198E 02	-0.7610E 01
CALCIUM					
	3	23.50	0.1171E 03	0.5034E 02	-0.6675E 02
	2	24.83	0.6868E 02	0.5494E 02	-0.1374E 02
	1	24.00	0.6765E 02	0.1518E 02	-0.5247E 02
	4	23.98	0.1030E 03	0.2355E 02	-0.7944E 02
	5	22.99	0.1025E 03	0.1435E 02	-0.8816E 02
	6	23.50	0.8369E 02	0.2116E 02	-0.6253E 02
MAGNESIUM					
	3	23.50	0.5025E 02	0.2186E 02	-0.2839E 02
	2	24.83	0.3373E 02	0.2299E 02	-0.1074E 02
	1	24.00	0.3721E 02	0.6532E 01	-0.3068E 02
	4	23.98	0.4597E 02	0.9540E 01	-0.3643E 02
	5	23.00	0.4550E 02	0.5654E 01	-0.3984E 02
	6	23.50	0.3612E 02	0.8711E 01	-0.2741E 02

TABLE A6. THE MASS (NUMBER*) OF EACH OTHER CONSTITUENT ENTERING BY IRRIGATION, LEAVING BY RUNOFF AND THE NET LOSS (OR GAIN) FOR EACH PLOT FOR EVENT NUMBER 1 DURING 1981. THE DURATION OF THE EVENT IS ALSO GIVEN AND WAS USED TO CALCULATE THE NET LOSS (GAIN) RATE.

CONSTITUENT	PLOT NO.	EVENT TIME HR.	IRRIG. MASS PER EVENT KG/HA	RUNOFF MASS PER EVENT KG/HA	NET MASS PER EVENT KG/HA
FECAL COLIFORM*					
	3	23.50	0.1415E 11	0.1010E 11	-0.4050E 10
	2	24.83	0.8348E 10	0.6228E 10	-0.2120E 10
	1	24.00	0.8325E 10	0.3613E 10	-0.4712E 10
	4	23.98	0.2516E 11	0.1091E 11	-0.1424E 11
	5	23.00	0.7643E 10	0.5084E 10	-0.2558E 10
	6	23.50	0.1970E 11	0.2060E 11	0.9006E 09
TOTAL COLIFORM*					
	3	23.50	0.3854E 13	0.8231E 13	0.4377E 13
	2	24.83	0.3441E 13	0.1203E 14	0.8592E 13
	1	24.00	0.2964E 13	0.4457E 13	0.1493E 13
	4	23.98	0.7112E 13	0.1591E 14	0.8798E 13
	5	23.00	0.5921E 13	0.1665E 14	0.1073E 14
	6	23.50	0.8913E 12	0.1689E 13	0.7973E 12
B. O. D.					
	3	23.50	0.4005E 02	0.9784E 01	-0.3027E 02
	2	24.83	0.3258E 02	0.4597E 01	-0.2798E 02
	1	24.00	0.3569E 02	0.1327E 01	-0.3436E 02
	4	23.98	0.4224E 02	0.9733E 00	-0.4127E 02
	5	23.00	0.4175E 02	0.5518E 00	-0.4120E 02
	6	23.50	0.4952E 02	0.2960E 01	-0.4656E 02
D. O.					
	3	23.50	0.5123E 02	0.1897E 02	-0.3226E 02
	2	24.83	0.3974E 02	0.1435E 02	-0.2539E 02
	1	24.00	0.4002E 02	0.3498E 01	-0.3653E 02
	4	23.98	0.5511E 02	0.7913E 01	-0.4719E 02
	5	23.00	0.5725E 02	0.3433E 01	-0.5382E 02
	6	23.50	0.5474E 02	0.1048E 02	-0.4426E 02
T. O. C.					
	3	23.50	0.5220E 02	0.4934E 02	-0.2863E 01
	2	24.83	0.3900E 02	0.5273E 02	0.1374E 02
	1	24.00	0.2447E 02	0.1347E 02	-0.1100E 02
	4	23.98	0.3421E 02	0.3981E 02	0.5598E 01
	5	23.00	0.4669E 02	0.2015E 02	-0.2654E 02
	6	23.50	0.5668E 02	0.2758E 02	-0.2910E 02
SUSPENDED SOLIDS					
	3	23.48	0.1229E 03	0.7686E 03	0.6456E 03
	2	24.83	0.2065E 03	0.9655E 03	0.7590E 03
	1	24.00	0.6619E 02	0.3495E 02	-0.3124E 02
	4	23.98	0.1402E 03	0.4705E 03	0.3303E 03
	5	23.00	0.1242E 03	0.4845E 01	-0.1194E 03
	6	23.50	0.7735E 02	0.2336E 03	0.1563E 03

* THE RESULTS FOR FECAL COLIFORM, FECAL STREPTOCOCCUS AND TOTAL COLIFORM ARE GIVEN AS NUMBER OF BACTERIA PER HECTARE RATHER THAN THE LISTED UNITS.

TABLE A7. THE MASS OF EACH CHEMICAL CONSTITUENT ENTERING BY IRRIGATION, LEAVING BY RUNOFF AND THE NET LOSS (OR GAIN) FOR EACH PLOT FOR EVENT NUMBER 2 DURING 1981. THE DURATION OF THE EVENT IS ALSO GIVEN AND WAS USED TO CALCULATE THE NET LOSS (GAIN) RATE.

CONSTITUENT	PLOT NO.	EVENT TIME HR.	IRRIG. MASS PER EVENT KG/HA	RUNOFF MASS PER EVENT KG/HA	NET MASS PER EVENT KG/HA
AMMONIA					
	3	22.98	0.1975E 00	0.2624E 00	0.6488E-01
	2	23.98	0.9054E-01	0.2265E 00	0.1359E 00
	1	23.98	0.1159E 00	0.1306E 00	0.1471E-01
	4	23.98	0.2346E 00	0.1141E 00	-0.1205E 00
	5	23.01	0.2362E 00	0.6441E 00	0.4079E 00
	6	24.98	0.3837E 00	0.5104E 00	0.1266E 00
NITRATE					
	3	22.98	0.4445E 00	0.7471E 00	0.3026E 00
	2	23.98	0.3389E 00	0.5405E 00	0.2015E 00
	1	23.98	0.5208E 00	0.3584E 00	-0.1624E 00
	4	23.98	0.6470E 00	0.9301E 00	0.2831E 00
	5	23.01	0.1019E 01	0.3236E 01	0.2217E 01
	6	24.98	0.6596E 00	0.3096E 01	0.2436E 01
T K N					
	3	22.98	0.5432E 01	0.2843E 01	-0.2589E 01
	2	23.97	0.1910E 01	0.3089E 01	0.1179E 01
	1	23.98	0.8042E 01	0.1565E 01	-0.6477E 01
	4	23.98	0.6585E 00	0.1077E 01	0.4183E 00
	5	23.00	0.7848E 00	0.6966E 01	0.6181E 01
	6	24.97	0.1077E 02	0.8644E 01	-0.2125E 01
ORTHO-P					
	3	22.98	0.3457E 00	0.1169E 01	0.8236E 00
	2	23.99	0.1778E 00	0.4744E 00	0.2966E 00
	1	23.98	0.4607E 00	0.3070E 00	-0.1538E 00
	4	23.98	0.4129E 00	0.2701E 00	-0.1428E 00
	5	23.00	0.4716E 00	0.2193E 01	0.1722E 01
	6	24.98	0.6047E 00	0.1969E 01	0.1364E 01
TOTAL-P					
	3	22.98	0.5432E 00	0.1471E 01	0.9276E 00
	2	23.98	0.2683E 00	0.7490E 00	0.4807E 00
	1	23.98	0.5766E 00	0.3770E 00	-0.1996E 00
	4	23.98	0.4140E 00	0.3503E 00	-0.6365E-01
	5	23.00	0.3939E 00	0.2884E 01	0.2491E 01
	6	24.98	0.1480E 01	0.2584E 01	0.1104E 01
SODIUM					
	3	22.98	0.6075E 02	0.3116E 02	-0.2959E 02
	2	23.98	0.5430E 02	0.2710E 02	-0.2721E 02
	1	23.98	0.8047E 02	0.1776E 02	-0.6271E 02
	4	23.98	0.8656E 02	0.7821E 01	-0.7874E 02
	5	23.00	0.1239E 03	0.4183E 02	-0.8208E 02
	6	24.98	0.1584E 03	0.7192E 02	-0.8651E 02
POTASSIUM					
	3	22.99	0.1136E 02	0.2170E 02	0.1034E 02
	2	23.98	0.7717E 01	0.1203E 02	0.4312E 01
	1	23.97	0.1844E 02	0.7774E 01	-0.1067E 02
	4	23.98	0.1535E 02	0.7477E 01	-0.7873E 01
	5	23.00	0.1885E 02	0.4198E 02	0.2313E 02
	6	24.99	0.2582E 02	0.4467E 02	0.1886E 02
CALCIUM					
	3	22.98	0.6173E 02	0.4120E 02	-0.2053E 02
	2	23.98	0.6712E 02	0.3852E 02	-0.2860E 02
	1	23.98	0.9959E 02	0.2609E 02	-0.7350E 02
	4	23.98	0.1095E 03	0.1180E 02	-0.9771E 02
	5	23.01	0.1483E 03	0.6168E 02	-0.8662E 02
	6	24.97	0.1693E 03	0.8109E 02	-0.8825E 02
MAGNESIUM					
	3	22.98	0.2914E 02	0.1525E 02	-0.1389E 02
	2	23.98	0.3209E 02	0.1622E 02	-0.1588E 02
	1	23.98	0.4634E 02	0.9821E 01	-0.3652E 02
	4	23.98	0.5005E 02	0.4898E 01	-0.4515E 02
	5	23.00	0.6826E 02	0.2431E 02	-0.4395E 02
	6	24.98	0.8525E 02	0.3663E 02	-0.4862E 02

TABLE A8. THE MASS (NUMBER*) OF EACH OTHER CONSTITUENT ENTERING BY IRRIGATION, LEAVING BY RUNOFF AND THE NET LOSS (OR GAIN) FOR EACH PLOT FOR EVENT NUMBER 2 DURING 1981. THE DURATION OF THE EVENT IS ALSO GIVEN AND WAS USED TO CALCULATE THE NET LOSS (GAIN) RATE.

CONSTITUENT	PLOT NO.	EVENT TIME HR.	IRRIG. MASS PER EVENT KG/HA	RUNOFF MASS PER EVENT KG/HA	NET MASS PER EVENT KG/HA
FECAL COLIFORM*					
	3	22.98	0.1570E 12	0.3681E 11	-0.1202E 12
	2	23.97	0.1867E 11	0.2114E 11	0.2466E 10
	1	23.98	0.2190E 11	0.1578E 11	-0.6116E 10
	4	23.98	0.2122E 11	0.8036E 10	-0.1318E 11
	5	23.00	0.1581E 11	0.3209E 11	0.1628E 11
	6	24.97	0.1365E 11	0.4159E 11	0.2794E 11
TOTAL COLIFORM*					
	3	22.99	0.1136E 13	0.1308E 14	0.1194E 14
	2	23.97	0.1428E 13	0.1097E 14	0.9546E 13
	1	23.98	0.5176E 13	0.7336E 13	0.2160E 13
	4	23.98	0.1581E 14	0.2289E 13	-0.1352E 14
	5	23.01	0.1366E 13	0.2182E 14	0.2045E 14
	6	24.98	0.4115E 13	0.6444E 13	0.2329E 13
B. O. D.					
	3	22.98	0.4455E 02	0.8962E 01	-0.3558E 02
	2	23.98	0.4155E 02	0.1278E 02	-0.2877E 02
	1	23.98	0.5897E 02	0.1121E 02	-0.4776E 02
	4	23.98	0.6009E 02	0.1044E 01	-0.5905E 02
	5	23.00	0.6683E 02	0.8141E 00	-0.6602E 02
	6	24.98	0.9364E 02	0.3369E 02	-0.5995E 02
D. O.					
	3	22.98	0.5186E 02	0.1694E 02	-0.3492E 02
	2	23.98	0.4405E 02	0.1629E 02	-0.2776E 02
	1	23.98	0.6484E 02	0.1064E 02	-0.5420E 02
	4	23.98	0.6598E 02	0.5247E 01	-0.6074E 02
	5	23.00	0.8867E 02	0.1976E 02	-0.6891E 02
	6	24.98	0.1123E 03	0.3434E 02	-0.7793E 02
T. O. C.					
	3	25.07	0.4436E 02	0.5128E 02	0.4629E 01
	2	23.97	0.2796E 02	0.3321E 02	0.5245E 01
	1	23.98	0.6571E 02	0.1202E 02	-0.5370E 02
	4	23.99	0.3389E 02	0.7696E 01	-0.2619E 02
	5	23.00	0.6339E 02	0.9182E 02	0.2843E 02
	6	24.98	0.8652E 02	0.6092E 02	-0.2560E 02
SUSPENDED SOLIDS					
	3	22.98	0.5136E 02	0.2979E 03	0.2465E 03
	2	23.98	0.3436E 02	0.2081E 03	0.1738E 03
	1	23.98	0.3261E 02	0.1501E 03	0.1175E 03
	4	23.98	0.2634E 01	0.5927E 02	0.5663E 02
	5	23.00	0.4667E 02	0.1770E 03	0.1303E 03
	6	24.98	0.1483E 03	0.1685E 03	0.2019E 02

* THE RESULTS FOR FECAL COLIFORM, FECAL STREPTOCOCCUS AND TOTAL COLIFORM ARE GIVEN AS NUMBER OF BACTERIA PER HECTARE RATHER THAN THE LISTED UNITS.

SELECTED WATER RESOURCES ABSTRACT

Input Transaction Form

1. *Report No.*

2.

3. *Accession No.*

4. *Title* Non-Point Pollution Control for Rangeland Wintering Livestock Operations (Ground Cover)

5. *Report Date*

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15. *Supplementary Notes*

16. *Abstract* Cow-calf cattle operators in the Rocky Mountain West commonly graze their cattle on the range during spring, summer and fall. They hold their cattle in semi-confinement areas during the winter where they are normally fed hay. The holding area is often the land upon which the hay was grown during the summer. This land is often alongside a stream and considered a potential source of non-point pollution for that stream. This study was established to quantify the amount of pollutant loss from cow-calf winter feeding operations and to examine the possibility that one hay crop on the land may retain more pollutants from the runoff water than another.

Three ground cover (hay crop) treatments with two replications were established using an alfalfa and grass mixture. The mixtures were those used by ranchers in the location of the test plots. After the plots were established in 1979, cattle were placed on them each winter and removed each spring for the next 3 years. The plots were irrigated twice each year. Irrigation and runoff flows were monitored and water samples taken for analysis.

An analysis of variance showed no significant difference between the ground cover treatment means for any constituent, although there was a trend toward better pollutant retention with the alfalfa fescue mixture. The effect of the first versus the second irrigation event was also analyzed with no significant difference found in the retention of pollutants although there seemed to be a trend toward a greater retention during the second event.

17a. *Descriptors*

non-point pollution control, rangeland wintering, livestock operations, ground cover

17c. *COWRR Field & Group*

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