

WATER QUALITY OF A RANGE WATERSHED IN SOUTHWESTERN
ALBERTA PRIOR TO ASPEN CLEARING

BY

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ABSTRACT

Water quality samples were obtained from an aspen-grassland watershed in southwestern Alberta over a period of 2 years. Sampling was done weekly, except monthly during the winter. The 65 samples were analyzed for Ca, Mg, Na, K, HCO_3 , SO_4 , and Cl. Specific conductance and sum of constituents were also determined. The mean concentration (mg/l) was 55(Ca), 21(Mg), 9(Na), 3(K), 280(HCO_3), 13(SO_4), and 1(Cl). The means for the specific conductance and the sum of constituents were found to be 466 $\mu\text{S}/\text{cm}$ and 250 mg/l, respectively. The estimates of pretreatment ionic concentrations presented here will serve as baselines for detecting changes in the main cations and anions subsequent to aspen clearing.

RESUME

Des échantillons sur la qualité de l'eau furent tirés d'un bassin-versant à prairie avec bosquets de peupliers faux-trembles pendant une période de 2 ans. Les échantillonnages furent faits chaque semaine, sauf pour les mois d'hiver où ils furent faits sur une base mensuelle. Les 65 échantillons furent analysés quant à leur teneur en Ca, Mg, Na, K, HCO_3 , SO_4 et en Cl. La "conductance" spécifique et la somme des constituants furent aussi déterminées. La concentration moyenne (mg/l) fut de 55(Ca), 21(Mg), 9(Na), 3(K), 280(HCO_3), 13(SO_4) et 1(Cl). Les moyennes de la conductance spécifique et de la somme des constituants furent de 466 $\mu\text{S}/\text{cm}$ et de 250 mg/l, respectivement. Les estimations de concentrations ioniques avant le traitement proposées ici serviront de fondement pour détecter les changements parmi les principaux cations et anions subséquents au traitement.

CONTENTS

	<u>Page</u>
INTRODUCTION	1
STUDY AREA AND METHODS	3
Study Area	3
Methods	4
RESULTS	5
DISCUSSION	5
ACKNOWLEDGMENTS	12
REFERENCES	13

INTRODUCTION

In early 1960, a research program (Alberta Watershed Research Program) in watershed management was initiated in Alberta to evaluate the effects of upstream land management on water production, regime, and quality. Several watersheds were considered, one of them being Streeter Basin Experimental Watershed (Fig. 1) located in the Porcupine Hills of southwestern Alberta. This watershed was selected in 1963 for studying the pre- and post-treatment hydrology of montane aspen forest and associated grasslands.

The original objectives of research at the time of selection have been described by Jeffrey (1965). These objectives were later modified because of the complexities encountered in accurately determining the groundwater hydrology (Swanson and Stevenson 1971). The revised goals to meet these objectives are listed in the approved treatment plan of Telfer and Golding (1976). According to this plan the proposed manipulation of vegetation to fulfill the objectives will consist of (1) patch-cutting in the aspen forest followed by breaking and seeding, or piling and burning or otherwise disposing of the slash to encourage sprouting; and (2) cutting strips through the aspen stands to cause sprouting and to provide travelways for animals to enable them to utilize all parts of the stands.

Water quality considerations have been emphasized from the very beginning because of the importance of forest lands and upper reaches in providing waters of excellent quality. The proposed manipulation of vegetation is to be conducted in such a way as to minimize damage to any other resource, especially scenery and water quality.

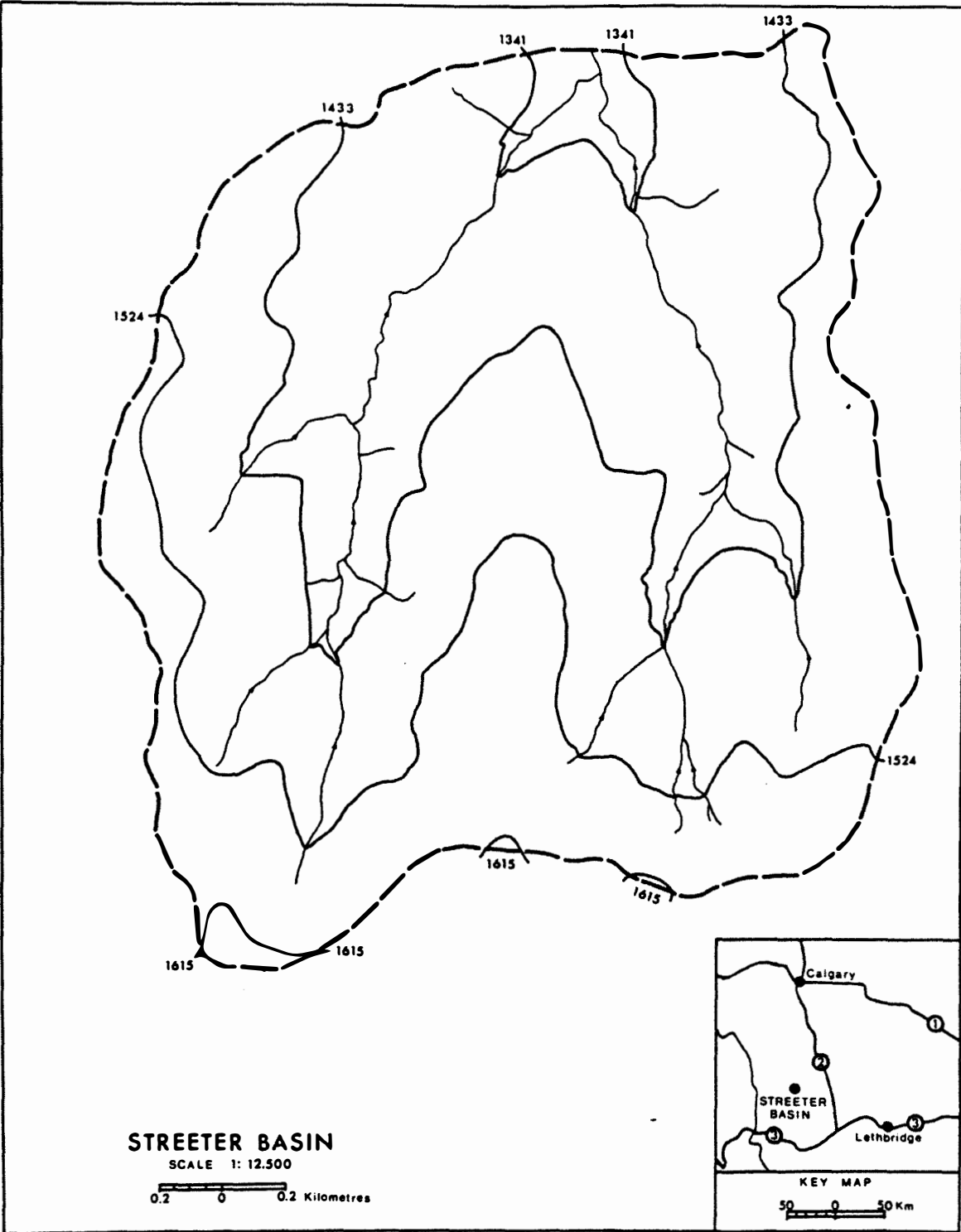


Fig. 1

For the present study intensive sampling was done during 1967 and 1968 at the main creek of Streeter Watershed to provide the baselines for water quality levels of inorganic constituents prior to treatment. The posttreatment data collection will evaluate the effects of the land disturbances on range management and watershed protection. Water quality data will be used to assess any damage occurring to the water environment as a result of modified upstream land management. Aspen were cleared in July and August 1976, and the treatment will be completed with the burning of slash in June 1977. Water quality data collection for the posttreatment phase has been started and is expected to be intensified during 1977 and subsequent years to determine any changes.

Mean streamflow and estimated yield of dissolved solids (inorganic solutes) for the period 1966 to 1971 have been presented previously (Singh 1976). The present study investigates the nature and concentration of these solutes for the pretreatment period.

STUDY AREA AND METHODS

STUDY AREA

The watershed is located in the Porcupine Hills of southwestern Alberta (50°7'N, 114°3'W) and covers an area of 6 km². It ranges in elevation from 1326 to 1661 m with rolling hills sloping up to 27%. The vegetation is scrub forest (mainly *Populus tremuloides* Michx.) and mixed grass (mainly *Festuca idahoensis* Elmer, *Danthonia parryi* Scribn. and *Phleum pratense* L.). The area is an important range habitat for cattle and wildlife. A description of the geology, soils, vegetation, and hydrology of the watershed is provided by Jeffrey (1965) and Singh et al. (1969).

The climate is moist sub-humid (Sanderson 1948) and seems to favor invasion of the prairie by poplar species (Dormaar and Lutwick 1966). Mean annual precipitation is 54.5 cm, of which about 65% comes as rain. Maximum temperatures occur in July (mean maximum 20.7°C, mean minimum 5.7°C). Southwest and west winds predominate; winter months are the windiest, averaging about 24 km/h compared with 14 km/h for the summer months. May to July is the period of high streamflow. Highest monthly yield occurs in June. A mean water yield of 7.6-8.9 cm seems representative of the area under its present vegetative cover (Singh et al. 1969).

METHODS

Water samples were collected on a weekly basis through the summer months and usually once during each winter month. Sixty-five samples were collected at the control weir and analyzed at the Water Quality Laboratory in Calgary according to the procedures established by the Inland Waters Branch (Simpkins 1970, personal communication). In brief the analytical methods were as follows: Ca (EDTA titration), Mg (calculated from Ca and hardness titration by difference), Na and K (flame emission), HCO₃ (potentiometric titration), SO₄ (BaCl₂ titration), Cl (colorimetrically by thiocyanate method), sum of constituents (sum of Ca, Mg, Na, K, SO₄, Cl, F, NO₃, SiO₂ and the CO₃ equivalent of HCO₃), and specific conductance (using conductivity meter).

The mean and standard error of the concentration of each of the cations (Ca, Mg, Na, and K), anions (HCO₃, SO₄ and Cl), and the sum of constituents were computed. These computations were done for the total samples

and also for the samples for each month. Data on specific conductance were similarly computed by months.

RESULTS

The data summary providing estimates of mean and standard error for the concentration (mg/l) of the chemical constituents is in Table 1. Calcium and Mg were the most abundant cations and bicarbonate the principal anion measured.

Mean specific conductance for each month ranged from 339.0 to 513.5 $\mu\text{S}/\text{cm}$, the lowest occurring in February and the highest in November (Table 2). The mean of the sum of constituents was lowest (182.0 mg/l) in February and highest (287.7 mg/l) in April. The greatest variation, as indicated by the standard error, occurred in March.

Monthly mean Ca concentration ranged from 26.7 to 67.6 mg/l (Table 3). Magnesium was the next most abundant cation, ranging in mean concentration from 12.8 to 24.4 mg/l. Sodium showed a monthly mean range of 5.2 to 11.0 mg/l and K from 2.2 to 6.4 mg/l.

Mean monthly values of HCO_3 ranged from 150.8 to 327.7 mg/l (Table 4) and was by far the most abundant ion. Sulphate and Cl ionic concentrations ranged from 10.2 to 14.7 and 0.5 to 1.8 mg/l, respectively.

DISCUSSION

Forests and rangelands are the natural regulators of nutrient accumulation and solute export from wildlands. Mineral nutrients stored in the growing vegetation are released and recycled when the vegetational debris is left on the ground for decay and decomposition. Some of the released

Table 1. Data summary of the analyzed inorganic constituents in the stream waters of Streeter basin .

Parameter	No. of Samples	Mean concentration (mg/ℓ)	Standard error (mg/ℓ)
Cations:			
Ca	65	54.5	1.5
Mg	65	21.5	0.5
Na	64	9.30	0.21
K	64	2.74	0.21
Anions:			
HCO ₃	64	280	6
SO ₄	65	13.0	0.4
Cl	64	0.76	0.15
Sum of constituents	64	250	5

Table 2. Specific conductance and sum of constituents in the stream waters of Streeter basin -

	Specific conductance			Sum of constituents		
	No. of Samples	Mean $\mu\text{S}/\text{cm}$ at 25°C	Standard error ($\mu\text{S}/\text{cm}$)	No. of Samples	Mean (mg/ℓ)	Standard error (mg/ℓ)
January	1	490.0		1	211.0	
February	1	339.0		1	182.0	
March	3	382.7	110.7	3	217.7	42.3
April	3	505.3	17.7	3	287.7	9.6
May	8	461.5	25.7	8	256.0	16.7
June	8	439.1	18.0	8	247.8	9.0
July	9	460.2	5.5	9	257.7	2.8
August	9	491.6	9.6	8	263.9	13.5
September	8	443.6	20.1	8	243.6	10.3
October	8	484.6	18.7	8	251.0	13.7
November	6	513.5	6.1	6	240.2	15.2
December	1	500.0		1	266.0	

Table 3. Concentration of cations in the stream waters of Streeter basin

Month	Ca			Mg			Na			K		
	No. of Samples	Mean mg/l	Standard error mg/l	No. of Samples	Mean mg/l	Standard error mg/l	No. of Samples	Mean mg/l	Standard error mg/l	No. of Samples	Mean mg/l	Standard error mg/l
January	1	42.5		1	19.6		1	8.8		1	3.5	
February	1	44.9		1	12.8		1	5.2		1	5.4	
March	3	26.7	1.5	3	14.4	7.1	3	6.7	2.5	3	6.4	3.9
April	3	67.6	3.8	3	23.4	0.4	3	9.2	0.2	3	2.7	0.4
May	8	56.3	3.8	8	21.5	1.2	8	8.5	0.6	8	3.1	0.6
June	8	55.4	3.2	8	22.2	0.5	8	8.3	0.6	8	2.2	0.04
July	9	57.1	1.4	9	22.7	0.1	9	10.0	0.4	9	2.3	0.05
August	9	59.0	2.7	9	22.0	1.5	8	9.9	0.2	8	2.6	0.3
September	8	57.1	2.7	8	18.8	1.9	8	10.0	0.3	8	2.2	0.05
October	8	54.7	5.5	8	22.2	1.0	8	9.9	0.2	8	2.6	0.2
November	6	46.7	6.1	6	24.4	0.3	6	10.0	0.2	6	2.5	0.1
December	1	61.0		1	23.5		1	11.0		1	2.5	

Table 4. Concentration of anions in the stream waters of Streeter basin

Month	HCO ₃			SO ₄			Cl		
	No. of Samples	Mean mg/l	Standard error mg/l	No. of Samples	Mean mg/l	Standard error mg/l	No. of Samples	Mean mg/l	Standard error mg/l
January	1	229.0		1	14.7		1	0.7	
February	1	204.0		1	10.2		1	1.3	
March	3	150.8	40.0	3	14.3	0.7	3	1.8	1.2
April	3	327.7	10.7	3	12.2	1.3	3	0.9	0.1
May	8	285.1	17.6	8	13.4	1.2	8	1.6	1.1
June	8	286.9	10.3	8	11.5	0.8	8	0.6	0.1
July	9	296.6	4.3	9	12.0	0.6	9	0.6	0.1
August	9	303.7	14.8	9	13.3	1.3	8	0.5	0.1
September	8	276.9	11.2	8	13.8	2.3	8	0.5	0.1
October	8	284.5	18.0	8	13.2	1.0	8	0.6	0.05
November	6	267.5	19.3	6	14.3	1.0	6	0.6	0.04
December				1	13.6		1	0.7	

nutrients are subject to the action of water and transported directly to the streams, while part of the nutrients infiltrate the soil and may eventually be released to the streams in subsurface flow and base flow.

Concentration levels of some ions (e.g. HCO_3) in Streeter Basin are already higher than the recommended concentrations for some uses of such natural waters (McKee and Wolf 1971). Any increase in the ionic levels due to aspen clearing and burning of slash should therefore be viewed with caution. The natural concentration levels of most ions in Streeter Basin are generally higher than those of the Marmot watershed (Singh and Kalra 1972) situated along the eastern slopes of the Canadian Rockies.

An excellent positive correlation between specific conductance and dissolved solids has been noticed in the Alberta watersheds (Singh and Kalra 1972, 1975). The fluctuations in specific conductance values therefore are indicative of the variations in the concentrations of the dissolved constituents presented in this report. The amount of streamflow also has an important effect on these concentrations because of the attendant dilution effects. The sum of constituents based on 202 samples averaged 173 mg/l for Marmot (Singh and Kalra 1972) compared with the average of 250 mg/l for Streeter computed from 64 samples. The river waters representing approximately 90% of the total streamflow in the United States have dissolved solids median concentration of 169 mg/l (Environmental Protection Agency 1973). The factors responsible for higher concentration levels in Streeter Basin have been discussed by Singh (1976).

High total dissolved solids in waters are objectionable because of possible physiological effects on man and wildlife, mineral taste, and

economic consequences (Environmental Protection Agency 1973). Consumer acceptance of mineralized waters has been observed to decrease in direct proportion to increased mineralization. Also, the high concentration of mineral salts, particularly sulphate and chloride, is associated with costly corrosion damage in water systems (Patterson and Banker 1968). Total dissolved solids in these samples are within the objective limits (<500 mg/l) and much less than the acceptable limits (1000 mg/l) in drinking water as recommended by the Canada Department of National Health and Welfare (1968). The American Water Works Association has established the goal of less than 200 mg/l dissolved solids (Bean 1968) to minimize the undesirable effect of minerals when water is heated and used in food preparation, laundry, rinsing, washing operations, cooling, industrial processing, etc. (Hartung and Tuepker 1969). Keeping dissolved materials at low levels reduces the problems when water is used for such purposes.

The natural flow of nutrients into streams will change as a result of clear-cutting and related practices (Singh and Kalra 1975). In view of the importance of mineral elements in plant growth and productivity, an intensive sampling program will be undertaken to study the loss of nutrients from wildlands as a consequence of such practices. Possible deterioration in sites due to nutrient losses has economic consequences because of reduced rate of plant growth and survival.

The estimates of pretreatment ionic concentrations presented here will serve as baselines for detecting any changes in the main cations and anions subsequent to treatment. There is also a need to consider the nutrient elements that occur in relatively small quantities but serve important functions in the mineral nutrition of plants.

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