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The IJC Menomonee River Watershed Study

Surface Water Quality From 1975 to 1979

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Volume 12

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PREFACE

The intent of this volume is to present a documentation of two years of supplemental monitoring and a summary and analysis of the surface water monitoring data from 1975 to 1979. The continuation of the monitoring program in 1978 and 1979 was designed to enhance the assessment of the amounts of critical pollutants washed off mixed and predominantly single land uses in the Menomonee River Watershed. Suspended solids, total-P, and lead were determined to be the pollutants of principal concern in the 1975 to 1977 monitoring program and the same pollutants are used in this volume to illustrate the behavior and amounts of contaminants during events, seasons and years.

The summary of the surface water quality presents mean seasonal baseflow and event flow weighted concentration values for 1975 to 1979. The analysis of the surface water quality describes the variability in the seasonal and annual loading values and evaluates the major factors affecting the differences in loading values between watersheds and seasons for 1975 to 1979.

Contents

*Detailed contents are presented at the beginning of each part.

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PART I

SURFACE WATER QUALITY FOR 1978 AND 1979

by

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Abstract

The quality of runoff from three mainstem river stations and eight predominantly single land use sites were monitored in 1978 and 1979. Automatic flow recording and sampling equipment were used at all the stations. Seasonal concentration data are documented for the suspended solids, total-P, soluble-P, chloride, lead, cadmium, conductivity and BOD_5. Bacteria counts determined at 28 sites are also included. Evaluations made on the concentration data include: 1) behavior of pollutant concentrations during events in the Watershed, and 2) determination of the source of high bacteria counts using the ratio of fecal coliform to fecal streptococcus.

Seasonal event and baseflow loadings are presented for both the pollutants and water. The loadings were estimated by a stratified random sampling model enhanced by a ratio estimator. The contributions of events to the total seasonal and annual loadings are evaluated. The land use factors affecting the variation in loadings between watersheds are also discussed. The event unit area loadings are generally higher from the more urbanized areas.

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I-1. INTRODUCTION

Water quality monitoring was continued for 1978 and 1979 at eight of the predominantly single and three of the mixed land use sites (mainstem river sites) in the Menomonee River Watershed. The objective of the additional monitoring was to enhance the water quality data collected between 1975 and 1977 and described in Volume 3 (1). The drought of 1976, equipment failure and delays in establishing sampling sites limited the collection of data at some of the critical land use tributary areas to one year. The monitoring program was continued at the eight predominantly single land use sites yielding the largest unit area loading values of the key parameters (suspended solids, total-P and lead). Three mainstem sites represented the integrated pollutant loadings from individual land use activities. The monitoring program in 1978 and 1979 also emphasized collection of samples during runoff events. The purpose of Part I of Volume 12 is to describe the monitoring program and the data collected in 1978 and 1979. Part I presents detailed summaries of the concentration and loading data. The statistical analysis of the factors affecting variations in unit loadings is reserved for Part II of Volume 12. Part II combines data from 1978 and 1979 with the first 3 years to provide a more meaningful long term analysis of the variations in unit loadings.

I-2 CONCLUSIONS

Mean seasonal event concentrations were similar for many stations during a given season, but the values usually fluctuated between seasons for each station. The mean event concentration for each season formed one or two groups containing three or more similar concentrations. Five or more total-P and soluble-P concentrations were similar for each season. Exceptionally high concentrations of soluble-P were usually found at Station 463001 and low concentrations were usually observed for Station 413011. Relatively high concentrations of chloride were found for Station 413615 while Station 463001 recorded the lowest chloride levels. The mean seasonal event concentrations for the mainstem river stations were in the same range as values measured at the predominantly single land use sites. The trends in the mean event concentrations between seasons reveals that cadmium, lead, chloride, suspended solids, conductivity, and BOD_5 were usually highest in the spring and lowest in the fall. The spring levels of chloride and conductivity were much larger than summer and fall levels. The higher mean event concentrations of total-P and soluble-P occurred either in the spring or fall. The mean event concentrations were always higher than mean baseflow concentrations except for chloride and conductivity. The chloride and conductivity levels were usually lower or about the same as baseflow levels. The importance of the nonpoint source contribution to the level of lead, cadmium, suspended solids, total-P, soluble-P, and BOD_5 in the river system is clearly demonstrated by the relatively high seasonal mean concentrations observed for events. The agricultural land use areas are a relatively important sources of soluble-P and highways contributed the highest levels of chloride.

The levels of suspended solids, total-P, soluble-P, and lead increased in the raising stage of an event hydrograph, while the levels of chloride usually decrease with increasing flow values. The variability of all the pollutants indicates that events can accurately be characterized only by collecting samples across the entire hydrograph.

The bacterial counts in the Menomonee River almost always exceeded the levels considered safe for bathing waters. Both human and animal fecal pollution were evident in the Watershed. Evidence of human fecal pollution was found for both the event and baseflow samples collected near combined sewer overflows and septic waste filter beds. Animals were determined to be the source of fecal bacteria in some of the agricultural and mixed land use drainage areas. High bacteria counts in the Menomonee River were observed near combined sewer flows, septic waste filter beds and feed lots. High counts were also observed in the highly urbanized Honey Creek subwatershed and in the ditches draining industrial sites.

Seasonal event unit area loadings varied between seasons for each station, but were similar between stations during a given season. The event unit area loadings were usually highest in spring and lowest in the fall. The water event unit area loadings in 1978 were the only exception with the highest loadings in the summer. Most of the sites had higher pollutant loadings in the spring. Ranking the stations during a given season revealed that the stations with the highest event unit area loadings usually contained the greatest amounts of connected imperviousness area. The larger percentages of connected imperviousness were associated with the more densely urbanized watershed. The stations with the highest pollutant loadings also had the highest water loadings.

The seasonal event unit area loadings measured at the mouth of the Menomonee River (413005) represented between 20 and 50 % of the total seasonal pollutant loadings in the spring and greater than 50 % of the total loadings in the summer and fall. The lower contribution of pollutants in the spring of 1978 and 1979 is related to the lower percent event water loading observed during the same period. The large portion of total loadings contributed by events indicated that land drainage is an important source of pollutants to the Menomonee River. The percent event pollutant and water loadings determined for four drainage areas of the Menomonee River (463001, 413007, 413006 and 413011) was highest at stations with the highest percent connected imperviousness. The percent event pollutant loading was usually greater than 75% for Stations 413011 and 413006. Remedial measures should be based on controlling land use activities which produce high pollutant concentrations and on those areas which, because of their high degree of connected imperviousness (urbanization) generate persistently high pollutant loadings.

I-3. MATERIALS AND PROCEDURES

Study Sites

Monitoring was continued in the Menomonee River Watershed during 1978 to 1979 at three mainstem river sites and at eight predominantly single land use sites. Between 1975 and 1977 the Menomonee River Pilot Watershed Project collected samples from nine mainstem river sites and ten predominantly single land use sites (1). The three mainstem river sites were chosen 1) to obtain loadings for the watershed as a whole and two of the principal tributaries and 2) to allow comparisons of loadings between the mixed land use areas and the predominantly single land use sites. The eight predominantly single land use sites -- representing the major land uses in the Menomonee River Watershed -- were selected for continued monitoring to allow further comparisons of loadings for the major land uses. Land use distributions at each of the eleven sites are shown in Table I-1. Other land use information has also been summarized in (2). The location of the monitoring stations is displayed in Fig. I-1. The sites are numbered according to the format used for the U.S. EPA STORET Data Base. In addition to the eleven automatic monitoring sites, 28 grab sampling sites were established for bacteriological surveys. The grab sampling sites were located above and below suspected sources of fecal bacteria. The description and location of the grab sampling sites is presented in Table I-2.

Sampling Equipment

The structures and automatic sampling equipment used between 1975 and 1977 were also used in 1978 and 1979. A detailed description of the sampling equipment is presented in Volume 3 (1). The three mainstem river stations (413005, 413006, 413007) and three of the predominantly single land use sites (463001, 413011, 413010) consisted of water and flow sampling equipment housed in a 3 x 3 meter stone or aluminum shelter. The sites were supplied with electricity and heated in the winter. The USGS PS-69 water sampler uses an impeller pump to draw water samples through a two centimeters plastic and copper intake line positioned about 15 centimeters above the stream bed. The height of the intake corresponded to the average water depth during summer base flows. A rotating arm on the sampler distributed the water to 72-wide mouth 1 liter polypropylene bottles. Stage height of the stream was measured using manometers manufactured by Scientific Instruments and recorded on a digital tape recorder (Fisher Porter). The microswitch on each manometer was set to actuate the sampler with small increases in stage height. The microswitch was adjusted for seasonal changes and baseflow levels. The samples were collected at hourly intervals and the sampling time was marked on the digital recorded tape.

Each predominantly single land use sampling site (413625, 413615, 683089, 413034, and 413616) consisted of a control structure, stage recorder, stilling well, automatic water sampler and a small protective enclosure. H flumes were used as control structures for sites 413625 and 413616 located in open ditches and Palmer-Bowlus flumes for sites 413615, 683089, and 413034 located in sewer pipes. An Instrument Specialties Company (ISCO) model 1680 automatic water

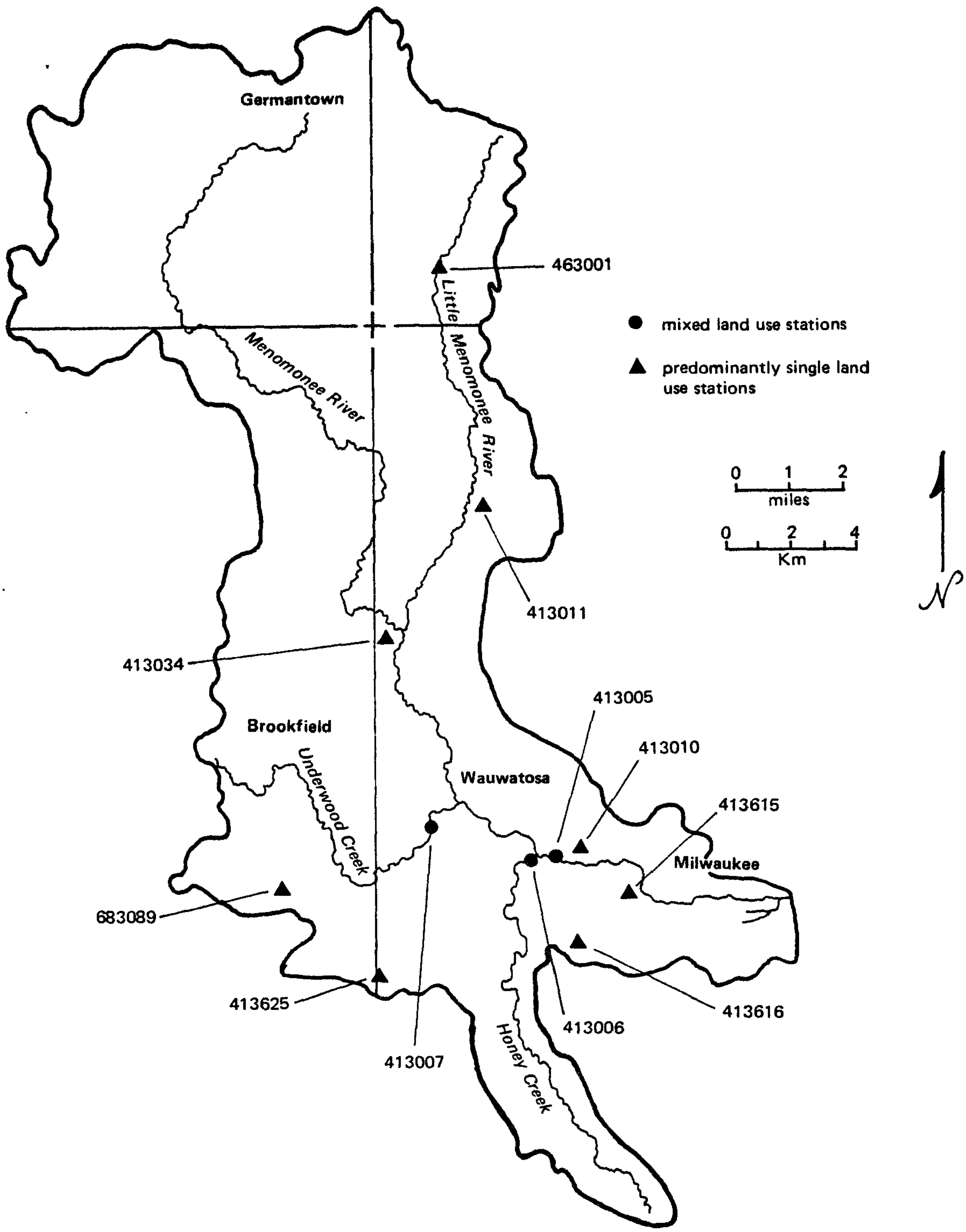

Figure I-1. Locations of monitoring stations within the Menomonee River Watershed.

Table 1-1. Land use categories (1975) in areas tributary to the monitoring stations*

STORET Number	Location	Area (ha)	Land use** distribution (%)														Imperviousness (%)	
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total	Connected
463001	Donges Bay Road, Mequon	2,144	0.0	0.8	1.9	0.1	6.9	1.5	1.6	43.8	30.2	9.8	2.3	0.6	0.0	0.6	4	1
413011	Noyes Creek at 91st Street	522	1.8	15.0	19.7	3.8	30.3	0.2	2.7	0.2	22.8	0.4	0.1	0.0	2.7	0.4	35	28
413007	Underwood Creek above Hwy. 45 off North Ave.	4,974	2.4	8.8	2.3	1.7	46.0	0.2	3.4	0.6	27	3.9	2.8	0.0	0.5	0.1	27	7
413006	Honey Creek 140m above confluence with MR	2,803	1.5	7.8	2.2	5.9	59.0	0.0	2.3	0.5	20	0.5	0.3	0.0	0.5	0.1	45	28
413005	70th Street Bridge on MR	32,205	2.0	6.5	1.7	1.9	28.0	0.8	3.3	15	30	6.1	3.3	0.1	0.3	0.4	22	9
413010	Schoonmaker Creek at Vliet Street	179	0.0	4.5	22.3	0.6	65.9	0.0	1.7	0.0	5.0	0.0	0.0	0.0	0.0	0.0	54	33
413615	Stadium Interchange, I-94	64	0.0	14.0	40.6	0.0	17.2	0.0	0.2	0.0	28.1	0.0	0.0	0.0	0.0	0.0	45	43
413616	Allis Chalmers Corp., City of West Allis	49	78.0	20.4	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	54	33
413625	New Berlin at 124th Street and Greenfield Ave.	224	0.0	2.7	11.2	0.9	0.0	56.6	2.7	0.0	25.0	0.9	0.0	0.0	0.0	0.0	22	0.3
413034	Wauwatosa, off Ferrick St.	110	22.7	49.1	8.2	0.0	7.3	0.0	0.0	0.0	12.7	0.0	0.0	0.0	0.	0.0	74	32
683089	Brookfield Square Shopping Center	61	0.0	60.7	4.9	0.0	8.2	0.0	0.0	0.0	26.2	0.0	0.0	0.0	0.0	0.0	50	45

* All stations have automatic sampling and continuous flow monitoring instruments.

** Land use categories in 1975 are: 1-industrial, 2-commercial, 3-roads, 4-high density residential, 5-medium density residential, 6-low density residential, 7-land under development, 8-row crops, 9-pasture and small grains (include park, recreational, institutional and unused land), 10-forested land and wood lots, 11-wetlands, 12-feedlots, 13-landfill and dumps, 14-water areas.

TABLE I-2. Descriptions of bacteria monitoring sites

Station Number	Potential Pollutant Sources	Site Descriptions
1	Feed Lots and Septic Tanks	West Branch of Menomonee River downstream from cattle feed lot and residential septic systems.
2	Agricultural Runoff	West Branch of Menomonee River, upstream from cattle feed lot and residential septic systems.
3	Agricultural Runoff and Industrial Discharges	Drainage ditch receiving agricultural and industrial discharges.
4	Agricultural Runoff	Menomonee River at Highway Q downstream from agricultural landuse activities.
5	Agricultural Runoff	Menomonee River at Friedstadt Road upstream from Germantown WWTP.
6	Residential Runoff	Honey Creek at McCarty Park.
7	Residential Runoff	Storm sewer outfall from residential area.
8	Residential and Commercial Runoff	Center Street storm sewer.
9	Residential and Industrial Runoff	124th Street storm sewer outfall.
10	Industrial Discharge	Seaman Company
11	Industrial Discharge	Drainage ditch in area of industrial septic system.
12	Industrial Discharge	Drainage ditch in area of industrial septic system.
13	Industrial Discharge	Drainage ditch in area of industrial septic system.

TABLE I-2. (continued)

Station Number	Potential Pollutant Sources	Site Descriptions
14	Industrial Runoff	Drainage ditch in Germantown Industrial Park.
15	Residential Runoff	Street gutter near Honey Creek station.
16	Residential and Agricultural Runoff	Menomonee River at Mill Road. Menomonee Falls WWTP are upstream.
17	Industrial, Commercial, Residential and CSO	Menomonee River at 13th Street in the Industrial Valley.
673001	Agricultural and Residential	Menomonee River at River Lane. Germantown WWTP upstream.
463001	Agricultural Runoff	Donges Bay Station
413008	Residential and Agricultural	Appleton Avenue Station
413005	All Types Land Uses and Some Sanitary By-passes	70th Street Station
683002	Most Types of Land Uses	124th Street Station, downtown WWTP.
683001	Most Types of Land Uses	Pilgram Road Station, upstream WWTP.
413011	Residential	Noyes Creek Station
413007	Most Types of Land Uses	Underwood Creek Station
413010	Residential	Schoonmacher Creek Station
413006	Residential and Commercial and Sanitary By-passes	Honey Creek Station
413009	Combined Sewer Overflow	Hawley Road Station

sampler fitted with a high speed pump drew samples through a one centimeter plastic tube positioned just above the bottom of the ditch or pipe and upstream from the control structure. The strainer on the end of the intake tube was removed because suspended solids were observed to accumulate on it. The water sampler was activated by a level actuator placed just above the level of the base flow in the ditch or storm sewer pipe. The sampler was set to collect samples at intervals determined by the event response of the site for each season and ranged from 10 min. to 2 hrs. The longest time intervals usually were applied to Station 413625 and the shortest to Station 413615 and 683089. A Steven's type A model 71 stage recorder was used to measure stage height in the stilling well. The sampling times were documented with a mark on the stage recorder strip chart.

Sampling Procedures

The objective of the project dictated that the emphasis be placed on sampling runoff events. During the course of runoff event sampling, collections were made to delineate the entire hydrograph and its corresponding pollutograph.

Sampling dates and numbers of samples collected for events sampled in 1978 and 1979 are presented in Tables I-3 and I-4. The relative magnitude of the events is represented by the rainfall amounts recorded at station 413005. Between five and seven samples were usually selected from the bottles available in the automatic water samplers. Selection was based on observation of the field hydrograph. An equal number of samples were chosen for the rising, peak and falling stages of the hydrograph. Samples were removed during or as quickly as possible after the event terminated. The samplers were manually turned off after the event was over.

For transport to the laboratory for analysis, the samples were placed in narrow mouth polypropylene bottles and mailed immediately. All samples were mailed in styrofoam containers fitted with an ice compartment. The wide-mouth bottles were replaced in the automatic samplers after washing with phosphorus- free detergent and rinsing with distilled water. Periodic baseflow samples were collected from Stations 463001, 413011, 413010, 413007, 413006, and 413005. Baseflow samples were not collected at the other stations because of intermittent or no flow during dry periods. The baseflow samples were collected by manually activating the automatic samplers.

The stage height was recorded continuously at all the sites. The stage recorder was periodically calibrated at stations without control structures. The stage heights on digital tape were translated into the flow values by the USGS and the strip charts were analyzed by the Wisconsin Department of Natural Resources (WDNR). The flow values for all the sites were stored on computer tape.

Table I-3. Dates, rainfall and number of samples collected for runoff events during 1978*

Date 1978*	Rainfall cm***	Number of samples+ collected at station:									
		413005	413006	413007	413010	413011	413034	413615	413625	463001	683089
4/3	1.4	5	5	2	2			10	5		3
4/5	3.5	6(B)	6(B)	4(B)	6(B)	5(B)		6(B)	5(B)	5(B)	4(B)
5/29	0.2						5				
6/16	7.9	12	6			5				10	
6/23	6.3							5			
6/25	0.8	5	5			5	5	4			
6/30	9.4	4	5	8	6		4		8	5	5
7/12	0.5				7						
7/17	0.5							4			
7/20	2.4				5		5		4		
7/26	1.6					5					5
7/31	2.6	(3B)	(3B)		(2B)						(3B)
8/15	1.6										(3B)
8/18	3.4						5				
8/24	0.5		(4B)								
8/27	1.6						5				
9/11	6.5	(3B)	(4B)						5	5	
9/20	2.7				5(B)						
10/2	0.9	4(B)	5(B)		4		5(B)	5	5		5(B)
10/5	1.7		5					7	5		
10/15	2.2	5	4								6
10/22	0.4	6									5
10/25	0.3	5						3			
11/13	1.0	7					6	7			
11/17	1.8						4				

* All samples analyzed for suspended solids, total P, soluble P, chloride and conductivity. The letter (B) represents 5 day BOD and a number inside the ( ) indicates it was the only parameter.

** Event starting dates at 413005 (70th Street).

*** Rainfall amounts at 413005 (70th Street).

+ Samples for 413005 represent 12 events out of 42 events observed on the flow record.

Table I-4. Dates, rainfall and number of samples collected for runoff events during 1979*

Date 1978*	Rainfall cm***	Number of samples+ collected at station: 413005	413006	413010	413007	463001	413011	413615	413625	683089	413034
3/2	Snowmelt	5	4					6		7	
3/6	Snowmelt	2	5								
3/13	Snowmelt	8	7		7			5	6		
3/16	Snowmelt	11	16		18	6	5	15	18		
3/23	1.4		7			16	6	2			
3/29	3.2	9	6		5	6	6	7	6	11	
4/11	3.2	4	6		6	6	6	6	6		
4/20	0.3		6								
4/24	4.6				6	4	6		6	6	6
5/2	0.9	7	6		6	6	6	6	6	6	6
5/13	0.8								6	6	6
5/30	2.8				6		6		6		6
6/5	0.1		6								
6/7	2.1		6				6			6	6
6/18	0.4							6		5	
6/20	0.7	6	7	7			6	6		6	5
6/28	2.4							6	6	5	6
7/3	1.7	6		6							
7/11	1.3	6	7				6	6	12	6	
7/22	0.1	6					7				
7/30	0.9	6	6					6	6		6
8/3	0.8							7			
8/4	2.1							6			
8/8	6.0	13		7	6	6			6	6	6
8/17	2.8		6		6	6	6				
8/22	1.8	6	6	14	12						
8/27	1.8			6	6		6				
10/19	2.0	7	7		6	14	13			6	
10/22	1.3	7	7			6				7	
10/31	0.2	7	7				6			7	
11/6	0.5	6					6			6	

* All samples analyzed for suspended solids, total P, soluble P, and chloride. The samples at 413005 (70th Street) were also analyzed for lead and cadmium.

** Event starting dates at 413005 (70th Street).

*** Rainfall amounts at 413005 (70th Street).

+ Samples for 413005 represent 18 events out of 32 events observed on the flow record.

Grab samples for bacteriological analysis were collected by hand holding a 300 ml plastic bottle in the stream. These samples were collected during events on April 6, April 18, May 12, May 15, June 20, August 18, and September 13 and 14 in 1978. Baseflow grab samples were collected on March 29, May 2 and November 1 in 1978. The samples were immediately mailed to the laboratory in ice-filled styrofoam containers.

Laboratory Analysis

The parameter list for the continued monitoring program focuses on the key pollutants identified in the results of the 1975 to 1977 monitoring program (1). All the samples collected in 1978 and 1979 were analysed for suspended solids, total-P, soluble-P, and chloride. Conductivity was measured on all the samples in 1978 and BOD_5 was determined on a few samples in 1978. Lead and cadmium concentrations were determined for all the samples collected at Station 413005 in 1979. A separate bottle was sent to the laboratory for the metals analysis. All analyses were conducted at the Wisconsin State Hygiene Laboratory located at the University of Wisconsin, Madison, some 130 km from the sampling sites. The parameters likely to undergo rapid transformations were processed upon arrival at the laboratory.

Analytical procedures used for analysis of phosphorus forms, lead, and cadmium were those recommended by the USEPA (3). Phosphorus forms were determined by approved autoanalyzer techniques (3). Atomic absorption spectroscopy utilizing a graphite furnance was chosen as the method of determination in most cases for metals (3). Procedures for determination of suspended solids, chloride, and BOD_5 are described in Standard Methods for Examination of Water and Wastewater (4). Conductivity was determined using a conductivity meter.

The data were filed in the storage data base in the WDNR computer mass storage files for reporting and statistical analysis.

Method of Calculating Loadings

A stratified random sampling model enhanced by a ratio estimator was used to estimate pollutant loading values at all the sites. The assumptions of the model are:

1. Simple random sampling of water quality within non-overlapping subpopulation or strata is possible.

2. Supplemental flow information is available rather than instantaneous flow values taken at those times when water quality samples were taken. The model produces load and variance estimates for each stratum and for the sum of the stratum. The same model was used to estimate loadings for the 1975 to 1977 monitoring data. The calculations were performed using a computer program developed by the WDNR. The method is described in more detail in Volume 3 (1).

I-4. RESULTS AND DISCUSSIONS

Flow and Concentration

Seasonal Concentration

Concentrations of eight parameters were monitored during runoff events and baseflow at 11 sites in 1978 and 1979. Flow was recorded continuously at the monitoring stations. These stations included three mainstem river sites and eight predominantly single land use sites that were included in the 1975 to 1977 Menomonee River Watershed monitoring program. The monitoring was begun in the spring of 1978 and ended in the fall of 1979. The concentration data were compiled and stored in the EPA STORET system. Flow records were maintained on computer tape and are available from the WDNR. The mean, daily, and monthly flow values for Stations 413005, 413010, 413006, 413007, 413011 and 463001 were tabulated in the U.S. Geological Survey Water Data Report for Wisconsin (5 and 6). Seasonal mean concentrations during runoff events and baseflow in 1978 and 1979 are presented in the appendix (Tables I-A-1 to I-A-22). The rainfall data for 1978 and 1979 is presented in Part II of Volume 12. Concentration data presented in the tables include the number of samples (frequency) used in the calculation of the seasonal mean values and the standard deviation about each mean. Seasons were defined as follows:

Summer - the period from June 1 to September 30.

Fall - the period from October 1 to December 21.

Winter - the period from December 22 to the onset of spring.

Spring - initiated by observation of the onset of sustained high flows. Varies from year to year and between stations in a particular year. Dates for the onset of spring were around April 3 for 1978 and March 2 for 1979 and always terminated on May 30 of each year.

Mean seasonal event concentrations of suspended solids, chloride, BOD , lead, cadmium and conductivity were usually highest in the spring and lowest in the fall for all sites. This trend was not observed for total-P and soluble-P. The highest soluble-P concentrations occurred either in the spring or the fall and the second highest concentration value always occurred in the summer. The total-P concentrations in 1978 were always highest in the spring, while the highest values occurred either in the summer or the fall in 1979. Mean seasonal concentrations are a function of the amount of pollutant available for washoff, and the volume of runoff. The higher mean seasonal concentrations in the spring suggest greater availability of pollutants because of the accumulation which occurs over the winter and a lack of protective vegetative cover on many of the pervious surfaces. The accumulation of road salt on the road surfaces during the winter is a definite factor in the higher levels of chloride and conductivity observed in the spring.

Although most of the mean seasonal event concentrations were similar among stations in a given season one or two sites in each season had an exceptionally high or low value. The highest soluble-P values were always observed at the agricultural site (463001) and the lowest total and soluble-P values were usually observed at the medium density residential site (413011). As was expected, the highest chloride concentrations were recorded at the freeway interchange site (413615) and the lowest in the agricultural sites (463001). Results from two sites (413625 and 413616) were not used in the ranking of the sites, because of contamination from point sources. The results from one station (413616) was affected by the discharge from the industrial waste treatment system on the site and the concentration of the phosphorus forms for station 413625 in the summer of 1979 was probably elevated by the direct dumping of fertilizer into the channel. Because of the point source discharge at station 413616 the site was not monitored in 1979.

The mean seasonal event concentrations were always higher than the baseflow values for suspended solids, total-P, soluble-P, cadmium, lead and BOD_5. However, the chloride and conductivity values were always higher for baseflow. The lower chloride values during events indicated that chloride on the streets is extensively diluted by runoff. High baseflow concentrations might reflect contamination of the groundwater by chloride. Evaluation of groundwater quality in Volume 7 (7) revealed high concentration of chlorides in the groundwater of the Menomonee River Watershed. The average ratio of "all seasons" mean event concentrations to baseflow concentrations range between 3 and 4 for suspended solids, total-P, soluble-P, cadmium and BOD_5. The importance of the nonpoint source contributions to the level of most of the pollutants in the river system is clearly documented by the relatively high concentrations of the key parameters during events.

Individual Event Flow and Concentrations

Discreet concentrations of suspended solids, total-P, soluble-P, and lead increased with increasing flows during individual events at Station 413005 (Tables I-A-26, I-A-27, & I-A-28). Again the chloride concentration decreased during events to levels about the same or less than baseflow values. The discreet concentration values for all the parameters except chloride were usually higher than the base flow values nearest the date of the event. The variability of all the parameters indicates that event concentrations can only be characterized by collecting samples across the entire hydrograph. The variabilities in the concentrations are reflected in the high standard deviation associated with the mean seasonal event concentrations. Although the impact of the higher event concentrations on beneficial uses of the receiving water cannot be quantified, nonpoint source pollution clearly makes an important contribution to the levels of the pollutants in the river system.

Bacterial Pollutants

Grab samples were obtained during events and baseflow at 28 locations to evaluate the levels and sources of fecal bacteria in the Menomonee River Watershed. The grab sampling sites were located above and below potential sources of fecal contamination; e.g. feedlots, combined sewer flows and septic drain fields. The fecal coliform and fecal streptococcus counts were recorded during the spring and summer of 1978 and are presented in Tables I-A-23, I-A-24, and I-A-25.

Relative to a bathing water criteria of 400 MFFCC/100 ML, the fecal coliform counts from the Menomonee River Watershed almost always exceeded the criteria during events. Less than half the values exceed the criteria during base flow. The event bacteria counts were usually higher than most of the base flow values. The Menomonee River system would be considered unsafe for body contact during events and for some periods of baseflow.

It has been found that the ratio of fecal coliform to fecal steptococcus varies by fecal source. A ratio in water of 4 or above suggests the fecal contamination is human and if below 0.7 the source is considered nonhuman. Both human and animal fecal pollution were evident in the watershed (Tables I-A-23, I-A-24, and I-A-25). High ratios indicated human fecal pollution was present for both event and base flow samples collected near combined sewer overflows and septic waste filter beds. Animals were the source of fecal bacteria in some of the agricultural and mixed land use drainage areas. High bacterial counts in the river system were observed near combined sewer overflows, septic waste filter beds and feedlots. High counts were also observed in the highly urbanized Honey Creek subwatershed and in ditches draining industrial sites.

Monitored Loading Data

Seasonal Loading

Seasonal loadings of water, suspended solids, total-P, and soluble-P were estimated for events and baseflow during 1978 to 1979. Most event loadings did not include baseflow loadings during events and thus provided estimates of nonpoint source pollution from the different land use areas. Seasonal baseflow loadings were calculated for both the times during and in between events as defined by the start and stop timers of the events. The event loadings were calculated by subtracting the seasonal baseflow loadings during events from the total seasonal event loading. Seasonal baseflow loadings were added to seasonal event loadings to estimate total seasonal loadings. The importance of nonpoint source pollution in the Watershed was determined by comparing total seasonal loadings with seasonal event loadings. Pollutant loadings were determined using the stratified random sampling model enhanced by a ratio estimator. The method is described in detail in Volume 3 (1). Water loadings were calculated by integration of flow values with time. Seasonal total loadings and event unit area loadings of water suspended solids, total-P, and soluble-P are presented in Tables I-A-29 to I-A-40. The percent event loading was determined by dividing the seasonal event loading by the total seasonal loading. The error estimated for each pollutant is presented as a 95% confidence interval. The mean flow weighted concentration for the season was calculated by dividing the seasonal event pollutant loading by seasonal event water loading. The event unit area loadings between seasons at each site were usually highest in the spring and lowest in the fall except for the water loadings in 1978. The event unit area loadings of water at six sites in 1978 were highest in the summer instead of the spring. However, four of the sites (413011, 413010, 413006, and 683089) with the highest water loading in the summer still maintained the highest pollutant loading in the spring. The mean seasonal event concentrations at the same sites were also highest in the spring. The event unit loadings were highest in the spring because the spring concentration values in 1978 were high enough to compensate for the lower water loadings in the spring. The spring was clearly the most critical time of the year for nonpoint source pollution during 1978 and 1979 in the Menomonee River Watershed. The total loadings had similar trends between seasons at a given site.

The seasonal event unit area pollutant loadings in a given season were compared to determine the most critical type of drainage areas in the Watershed. Many of the sites had similar loadings in the spring and summer. Stations 413005, 463001, 413007 and 413625 show lower event unit area loadings than other stations. These stations also have the lowest values of percent connected imperviousness (Table I-1). Station 413615 usually had the highest event unit area loading. The rankings of the sites revealed that the highly urbanized drainage areas in the Menomonee River Watershed are the most critical sources of nonpoint source pollution. The event unit area loadings for stations 413034 and 413616 were not used in the ranking analyses. The concentration values from 413616 were elevated by point source contamination and the flow values at 413034 were modified by a large cooling water system in the storm sewer.

The seasonal event loadings represent the contribution of nonpoint source pollution to the total seasonal loading. The importance of the nonpoint source contribution for the entire watershed was measured at the mainstem station 413005. This site is at the mouth of the Menomonee River. The percent of the pollutant event loadings at station 413005 was between 20 and 50 percent in the spring and usually greater than 50 % in the summer and fall. The lower percent event water and pollutant loadings were expected in the spring since snow melt and higher ground water tables sustained relatively high base flows in the spring. The high percent event values indicate land drainage from the Watershed is an important source of pollution to the Menomonee River.

The percent of the total loadings contributed by events were also determined for four of the sites (413011, 413006, 413007, and 463001) located on the perennial streams tributary to the Menomonee River. The percent event water loadings were always higher for Stations 413011 and 413006 which drain more highly urbanized subwatersheds. The events produced more runoff per unit area from the subwatersheds with a greater amount of percent connected imperviousness. The percent event loading of suspended solids, total-P, and soluble-P was almost always greater than 50 % at all the sites except for Station 463001 in 1979. The percent event was less than 50 % for all suspended solid loadings and the fall phosphorus loadings at Station 463001 in 1979 because of the low percent event water loading in all the seasons and the similarity of the event and baseflow suspended solids concentrations. The percent event loading was usually greater than 75 % in the most urbanized drainage areas (413011 and 413006). The high contributions of event loadings observed at the four tributary drainage areas further emphasize the importance of nonpoint source pollution in the Menomonee River Watershed, which is representative of most urbanized areas.

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Appendix A. Surface Water Quality for 1978 and 1979.

Appendix I-A contains tabular materials which are grouped in the following manner to correspond to the order shown in the main text.

Table Nos.	Description
I-A-1 to I-A-22	Seasonal mean concentrations of pollutants during baseflow and events.
I-A-23 to I-A-25	Bacterial counts in baseflow and event samples.
I-A-26 to I-A-28	Flow and pollutant concentrations for selected events and baseflow at station 413005.
I-A-29 to I-A-37	Seasonal and annual total loading and event unit area loading for water, suspended solids, total-P and soluble-P.

Table I-A-I. Seasonal mean concentrations (mg/L), standard deviations, and frequency of sampling for BOD-5 day during 1978 baseflow

STORET NUMBER	SPR 78	SUM 78	FALL 78	ALL SEASONS
		Frequency		
463001	1.	1.		2.
413011	1.	1.		2.
413007	1.	1.		2.
413006	1.	1.		2.
413005	2.	1.		3.
413010	2.		4.	6.
		Mean concentration		
463001	1.20	2.90		2.05
413011	1.20	2.50		1.85
413007	1.60	4.10		2.85
413006	.12	2.90		1.51
413005	5.60	3.30		4.83
413010	10.60		14.00	12.87
		Standard deviation		
463001	.00	.00		1.20
413011	.00	.00		.92
413007	.00	.00		1.77
413006	.00	.00		1.97
413005	5.09	.00		3.84
413010	13.29		5.23	7.41

Table I-A-2. Seasonal mean concentrations (mg/L), standard deviations, and frequency of sampling for BOD-5 day during 1978 events

STORET NUMBER	SPR 78	SUM 78	FALL 78	ALL SEASONS
		Frequency		
463001	4.			4.
413011	4.			4.
413007	5.			5.
413006	10.	11.	2.	23.
413005	10.	10.	2.	22.
413010	7.	8.	4.	19.
413615	11.			11.
413616				
413625	11.			11.
413034				
683089	8.	9.	3.	20
		Mean concentration		
463001	9.37			9.37
413011	7.75			7.75
413007	12.36			12.36
413006	13.59	10.83	7.10	11.70
413005	9.99	11.12	6.10	10.15
413010	27.33	13.64	14.10	18.78
413615	15.65			15.65
413616				
413625	5.75			5.75
413034				
683089	16.87	15.71	7.37	14.92
		Standard deviation		
463001	3.08			3.08
413011	2.94			2.94
413007	4.98			4.98
413006	9.28	3.91	.14	6.79
413005	1.81	6.49	.57	4.64
413010	13.93	8.81	5.10	12.01
413615	10.81			10.81
413616				
413625	4.63			4.63
413034				
683089	8.99	11.26	.75	9.70

Table I-A-3. Seasonal mean concentrations (mg/L), standard deviations, and frequency of sampling for suspended solids during 1978 baseflow

STORET NUMBER	SPR 78	SUM 78	FALL 78	ALL SEASONS
		Frequency		
463001	3.	3.	1.	7.
413011	3.	8.	1.	12.
413007	6.	3.	1.	10.
413006	3.	12.	1.	16.
413005	4.	2.	2.	8.
413010	4.		4.	8.
		Mean concentration		
463001	10.0	66.0	140.0	52.5
413011	8.6	69.1	119.0	58.1
413007	54.6	50.6	101.0	58.1
413006	8.6	34.3	82.0	32.5
413005	92.0	10.0	141.5	83.7
413010	113.0		82.0	97.5
		Standard deviation		
463001	7.2	49.1	.0	55.6
413011	7.0	58.3	.0	57.1
413007	46.2	40.8	.0	42.2
413006	8.0	14.3	.0	20.9
413005	144.5	1.4	14.8	107.3
413010	166.4		64.0	117.9

Table I-A-4. Seasonal mean concentrations (mg/L), standard deviations, and frequency of sampling for suspended solids during 1978 events

STORET NUMBER	SPR 78	SUM 78	FALL 78	ALL SEASONS
		Frequency		
463001	5.	19.		24.
413011	6.	15.		21.
413007	9.	8.		17.
413006	11.	24.	14.	49.
413005	11.	21.	27.	59.
413010	18.	23.	4.	45.
413615	16.	13.	21.	50.
413616	4.	20.	5.	29.
413625	15.	17.	17.	49.
413034		9.	4.	13.
683089	11.	15.	25.	51.
		Mean concentration		
463001	220.6	224.4		223.6
413011	265.0	79.4		132.4
413007	262.2	338.6		298.1
413006	400.6	97.1	50.3	151.9
413005	321.8	196.9	102.1	176.8
413010	812.6	179.7	82.0	424.2
413615	752.3	142.6	87.2	314.4
413616	42.5	74.9	25.6	61.9
413625	381.1	347.4	160.6	292.9
413034		89.0	68.5	82.6
683089	223.82	147.6	294.9	187.2
		Standard deviation		
463001	178.2	304.5		279.4
413011	350.9	52.9		200.3
413007	255.0	571.1		420.4
413006	361.9	117.5	39.4	230.2
413005	128.5	114.8	45.3	122.6
413010	634.1	133.8	64.0	517.9
413615	861.0	125.3	74.8	570.6
413616	29.8	43.4	5.6	42.3
413625	580.2	365.8	116.0	396.1
413034		87.2	21.2	72.7
683089	341.0	169.9	225.3	237.7

Table I-A-5. Seasonal mean concentrations (mg/L), standard deviations, and frequency of sampling for total-P during 1978 baseflow

STORET NUMBER	SPR 78	SUM 78	FALL 78	ALL SEASONS
		Frequency		
463001	3.	3.	1.	7.
413011	3.	8.	1.	12.
413007	3.	3.	1.	7.
413006	3.	4.	1.	8.
413005	4.	2.	2.	8.
413010	4.		4.	8.
		Mean concentration		
463001	.10	.10	.04	.09
413011	.07	.11	.06	.10
413007	.10	.06	.02	.07
413006	.09	.09	.12	.09
413005	.23	.19	.14	.19
413010	.21		.32	.23
		Standard deviation		
463001	.07	.02	.00	.05
413011	.05	.13	.00	.10
413007	.06	.02	.00	.05
413006	.06	.03	.00	.04
413005	.19	.08	.06	.13
413010	.20		.14	.23

Table I-A-6. Seasonal mean concentrations (mg/L), standard deviations, and frequency of sampling for total-P during 1978 events

STORET NUMBER	SPR 78	SUM 78	FALL 78	ALL SEASONS
		Frequency		
463001	5.	19.		24.
413011	6.	15.		21.
413007	6.	8.		14.
413006	11.	16.	14.	41.
413005	11.	21.	27.	59.
413010	18.	23.	4.	45.
413615	16.	13.	21.	50.
413616	4.	20.	5.	29.
413625	16.	17.	17.	50.
413034		9.	4.	13.
683089	11.	15.	25.	51.
		Mean concentration		
463001	.45	.43		.43
413011	.28	.09		.14
413007	.50	.33		.40
413006	.64	.25	.19	.34
413005	.47	.28	.26	.30
413010	1.57	.41	.32	.87
413615	.70	.24	.19	.37
413616	.45	.33	.29	.34
413625	.38	.34	.27	.33
413034		.23	.19	.22
683089	.40	.19	.14	.21
		Standard deviation		
463001	.26	.33		.32
413011	.23	.05		.15
413007	.32	.37		.35
413006	.29	.25	.17	.30
413005	.13	.12	.26	.21
413010	1.19	.23	.14	.96
413615	.70	.18	.11	.47
413616	.23	.11	.04	.13
413625	.41	.21	.16	.27
413034		.10	.03	.08
683089	.33	.14	.10	.21

Table I-A-7. Seasonal mean concentrations (mg/L), standard deviations, and frequency of sampling for soluble-P during 1978 baseflow

STORET NUMBER	SPR 78	SUM 78	FALL 78	ALL SEASONS
		Frequency		
463001	3.	3.	1.	7.
413011	3.	8.	1.	12.
413007	3.	3.	1.	7.
413006	3.	4.	1.	8.
413005	4.	2.	2.	8.
413010	4.		4.	8.
		Mean concentration		
463001	.06	.04	.01	.04
413011	.02	.01	.01	.01
413007	.03	.01	.00	.02
413006	.05	.03	.04	.04
413005	.05	.09	.03	.05
413010	.03		.05	.04
		Standard deviation		
463001	.05	.02	.00	.03
413011	.01	.01	.00	.01
413007	.02	.01	.00	.02
413006	.05	.02	.00	.03
413005	.03	.03	.02	.03
413010	.02		.02	.02

Table I-A-8. Seasonal mean concentrations (mg/L), standard deviations, and frequency of sampling for soluble-P during 1978 events

STORET NUMBER	SPR 78	SUM 78	FALL 78	ALL SEASONS
		Frequency		
463001	5.	19.		24.
413011	6.	15.		21.
413007	6.	8.		14.
413006	11.	16.	14.	41.
413005	11.	21.	27.	59.
413010	18.	23.	4.	45.
413615	16.	13.	21.	50.
413616	4.	20.	5.	29.
413625	16.	17.	17.	50.
413034		9.	4.	13.
683089	11.	15.	25.	51.
		Mean Concentration		
463001	.10	.20		.18
413011	.03	.01		.02
413007	.04	.04		.04
413006	.13	.04	.07	.07
413005	.05	.06	.08	.07
413010	.05	.05	.05	.05
413615	.01	.03	.03	.03
413616	.17	.16	.14	.16
413625	.04	.05	.11	.07
413034		.07	.04	.06
683089	.07	.04	.03	.04
		Standard deviation		
463001	.03	.30		.27
413011	.02	.01		.02
413007	.03	.02		.02
413006	.07	.03	.10	.08
413005	.02	.02	.09	.06
413010	.04	.06	.02	.05
413615	.02	.03	.03	.03
413616	.07	.08	.02	.07
413625	.02	.04	.09	.06
413034		.04	.00	.03
683089	.07	.02	.03	.04

Table I-A-9. Seasonal mean concentrations (mg/L), standard deviations, and frequency of sampling for chlorides during 1978 baseflow

STORET NUMBER	SPR 78	SUM 78	FALL 78	ALL SEASONS
		Frequency		
463001	3.	3.	1.	7.
413011	3.	8.	1.	12.
413007	6.	3.	1.	10.
413006	3.	4.	1.	8.
413005	4.	2.	2.	8.
413010	4.		4.	8.
		Mean concentration		
463001	36.33	38.67	32.00	36.29
413011	285.00	97.38	175.00	150.75
413007	192.50	208.33	235.00	201.50
413006	286.67	155.00	105.00	197.50
413005	137.50	122.50	134.00	132.88
413010	447.50		18.00	232.75
		Standard deviation		
463001	12.50	1.53	.00	7.72
413011	39.69	53.74	.00	95.74
413007	49.97	18.93	.00	40.76
413006	43.68	40.93	.00	82.16
413005	18.48	17.68	15.56	16.40
413010	251.45		15.68	282.68

Table I-A-10. Seasonal mean concentrations (mg/L), standard deviations, and frequency of sampling for chlorides during 1978 events

STORET NUMBER	SPR 78	SUM 78	FALL 78	ALL SEASONS
		Frequency		
463001	5.	19.		24.
413011	6.	15.		21.
413007	9.	8.		17.
413006	11.	16.	14.	41.
413005	11.	21.	27.	59.
413010	18.	23.	4.	45.
413615	16.	13.	20.	49.
413616	4.	20.	5.	29.
413625	16.	17.	16.	49.
413034		9.	4.	13.
683089	11.	15.	25.	51.
		Mean concentration		
463001	56.00	33.84		38.46
413011	148.67	82.20		101.19
413007	183.00	49.12		120.00
413006	110.27	69.00	40.00	70.17
413005	134.82	60.48	111.15	97.53
413010	128.11	26.54	18.00	66.41
413615	314.94	63.54	60.50	144.39
413616	51.50	31.30	42.80	36.07
413625	102.94	54.12	101.12	85.41
413034		13.67	36.00	20.54
683089	232.55	103.40	24.56	92.61
		Standard deviation		
463001	7.48	8.21		12.13
413011	63.33	30.89		51.16
413007	42.31	14.09		75.67
413006	47.17	44.08	31.72	48.72
413005	27.39	33.60	21.21	39.59
413010	132.15	24.06	15.68	98.26
413615	420.97	62.53	79.25	270.63
413616	11.12	9.61	4.32	11.70
413625	32.81	44.76	27.65	42.13
413034		10.84	5.94	14.22
683089	245.22	358.97	24.46	234.63

Table I-A-11. Seasonal mean concentrations (umhos/cm), standard deviations, and frequency of sampling for conductivity during 1979 baseflow

STORET NUMBER	SPR 79	SUM 79	FALL 79	ALL SEASONS
		Frequency		
463001	6.	5.	2.	13.
413011	7.	3.	2.	12.
413007	7.	5.	2.	14.
413006	6.	6.	2.	14.
413005	5.	4.	2.	11.
		Mean concentration		
463001	626.33	641.80	690.50	642.15
413011	1437.00	1148.00	782.00	1255.00
413007	1249.14	1155.00	986.00	1177.93
413006	1435.33	826.33	764.00	1078.43
413005	883.40	990.50	1020.00	947.18
		Standard deviation		
463001	87.87	41.14	28.99	66.07
413011	375.10	28.62	0.00	376.53
413007	252.84	256.19	118.79	243.69
413006	292.95	89.33	104.65	374.50
413005	53.65	103.70	.00	90.68

Table I-A-12. Seasonal mean concentrations (umhos/cm), standard deviations, and frequency of sampling for conductivity during 1979 events

STORET NUMBER	SPR 79	SUM 79	FALL 79	ALL SEASONS
		Frequency		
463001	38.	10.	19.	67.
413011	39.	43.	38.	120.
413007	52.	18.	6.	76.
413006	55.	24.	19.	98.
413005	33.	45.	32.	110.
413010		46.		46.
413615	28.	42.		70.
413625	58.	30.		88.
413034	24.	28.		52.
683089	36.	40.	32.	108.
		Mean concentration		
463001	524.13	603.00	700.53	585.93
413011	608.28	518.53	514.29	546.36
413007	759.79	404.17	505.00	655.45
413006	936.64	342.54	266.16	662.84
413005	800.94	636.33	797.66	732.65
413010		212.54		212.54
413615	1105.07	477.93		728.79
413625	486.21	444.07		471.84
413034	205.79	206.64		206.25
683089	931.92	454.55	237.03	549.22
		Standard deviation		
463001	101.22	49.90	28.77	111.05
413011	276.99	219.62	224.96	243.16
413007	178.79	120.15	63.17	223.13
413006	596.91	175.21	111.37	554.60
413005	378.99	123.84	150.81	247.61
413010		112.01		112.01
413615	681.82	580.15		691.13
413625	119.61	249.40		174.68
413034	113.72	88.62		99.95
683089	1014.47	466.90	305.41	724.49

Table I-A-13. Seasonal mean concentrations (mg/l), standard deviations, and frequency of sampling for suspended solids during 1979 baseflow

STORET NUMBER	SPR 79	SUM 79	FALL 79	ALL SEASONS
		Frequency		
463001	6.	5.	2.	13.
413011	7.	3.	2.	12.
413007	7.	5.	2.	14.
413006	6.	6.	2.	14.
413005	5.	4.	4.	13.
		Mean concentration		
463001	126.3	118.0	124.0	122.7
413011	133.2	85.0	92.5	114.4
413007	125.7	66.4	86.0	98.8
413006	129.3	62.1	72.5	92.4
413005	164.0	68.2	58.2	102.0
		Standard deviation		
463001	37.1	31.5	4.2	30.3
413011	30.9	48.1	7.7	38.7
413007	20.3	40.4	22.6	39.4
413006	44.6	21.2	9.1	45.3
413005	45.1	17.4	61.3	65.6

Table I-A-14. Seasonal mean concentrations (mg/L), standard deviations, and frequency of sampling for suspended solids during 1979 events

STORET NUMBER	SPR 79	SUM 79	FALL 79	ALL SEASONS
		Frequency		
463001	38.	10.	19.	67.
413011	39.	43.	38.	120.
413007	52.	18.	6.	76.
413006	56.	25.	20.	101.
413005	33.	45.	32.	110.
413010		46.		46.
413615	30.	43.		73.
413625	58.	30.		88.
413034	24.	29.		53.
683089	36.	40.	32.	108.
		Mean concentration		
463001	112.3	128.9	102.6	112.0
413011	179.0	133.7	96.1	136.5
413007	226.5	222.5	72.1	213.3
413006	189.3	133.0	273.4	192.0
413005	209.6	123.4	91.5	140.0
413010		202.7		202.7
413615	229.1	176.6		198.2
413625	502.5	346.0		449.1
413034	309.0	455.9		389.4
683089	158.4	142.0	45.6	118.9
		Standard deviation		
463001	73.7	62.8	18.1	61.2
413011	210.2	230.4	126.3	197.3
413007	122.4	216.1	28.4	150.2
413006	186.2	123.2	238.0	188.9
413005	104.6	71.1	31.3	88.3
413010		209.6		209.6
413615	214.7	165.3		187.6
413625	480.3	467.2		479.0
413034	345.9	832.1		656.6
683089	164.2	193.2	37.4	158.6

Table I-A-15. Seasonal mean concentrations (mg/L), standard deviations, and frequency of sampling for total-P during 1979 baseflow

STORET NUMBER	SPR 79	SUM 79	FALL 79	ALL SEASONS
		Frequency		
463001	6.	5.	2.	13.
413011	7.	3.	2.	12.
413007	7.	5.	2.	14.
413006	6.	6.	2.	14.
413005	5.	4.	2.	11.
		Mean concentration		
463001	.08	.09	.06	.08
413011	.02	.04	.05	.03
413007	.07	.05	.05	.06
413006	.06	.06	.03	.06
413005	.08	.10	.07	.09
		Standard deviation		
463001	.06	.01	.01	.04
413011	.01	.01	.01	.01
413007	.05	.02	.01	.04
413006	.06	.04	.01	.05
413005	.01	.04	.01	.03

Table I-A-16. Seasonal mean concentrations (mg/L), standard deviations, and frequency of sampling for total-P during 1979 events

STORET NUMBER	SPR 79	SUM 79	FALL 79	ALL SEASONS
		Frequency		
463001	38.	10.	19.	67.
413011	39.	43.	38.	120.
413007	52.	18.	6.	76.
413006	56.	25.	20.	101.
413005	33.	45.	32.	110.
413010		46.		46.
413615	30.	43.		73.
413625	58.	30.		88.
413034	24.	29.		53.
683089	36.	40.	32.	108.
		Mean concentration		
463001	.22	.32	.13	.21
413011	.14	.13	.16	.14
413007	.26	.30	.17	.26
413006	.23	.25	.34	.25
413005	.18	.20	.19	.19
413010		.29		.29
413615	.22	.25		.24
413625	.29	2.66		1.10
413034	.18	.42		.31
683089	.12	.23	.16	.17
		Standard deviation		
463001	.09	.13	.04	.11
413011	.11	.12	.12	.12
413007	.18	.14	.04	.17
413006	.11	.20	.17	.16
413005	.12	.07	.16	.12
413010		.16		.16
413615	.13	.15		.14
413625	.23	5.62		3.44
413034	.14	.57		.44
683089	.09	.16	.20	.16

Table I-A-17. Seasonal mean concentrations (mg/L), standard deviations, and frequency of sampling for soluble-P during 1979 baseflow

STORET NUMBER	SPR 79	SUM 79	FALL 79	ALL SEASONS
		Frequency		
463001	6.	5.	2.	13.
413011	7.	3.	2.	12.
413007	7.	5.	2.	14.
413006	6.	6.	2.	14.
413005	5.	4.	8.	17.
		Mean concentration		
463001	.02	.02	.01	.02
413011	.00	.00	.01	.00
413007	.01	.01	.01	.01
413006	.01	.01	.00	.01
413005	.01	.03	.01	.01
		Standard deviation		
463001	.01	.01	.00	.01
413011	.00	.00	.00	.00
413007	.02	.00	.00	.01
413006	.02	.01	.00	.01
413005	.01	.01	.00	.01

Table I-A-18. Seasonal mean concentrations (mg/L), standard deviations, and frequency of sampling for soluble-P during 1979 events

STORET NUMBER	SPR 79	SUM 79	FALL 79	ALL SEASONS
		Frequency		
463001	38.	10.	19.	67.
413011	39.	43.	38.	120.
413007	52.	18.	6.	76.
413006	56.	25.	20.	101.
413005	33.	45.	32.	110.
413010		46.		46.
413615	30.	43.		73.
413625	58.	30.		88.
413034	24.	29.		53.
683089	36.	40.	31.	107.
		Mean concentration		
463001	.12	.09	.03	.09
413011	.02	.02	.04	.03
413007	.06	.04	.03	.05
413006	.06	.04	.03	.05
413005	.02	.04	.05	.04
413010		.05		.05
413615	.04	.04		.04
413625	.03	1.64		.58
413034	.02	.03		.03
683089	.01	.04	.06	.04
		Standard deviation		
463001	.08	.06	.02	.08
413011	.01	.01	.03	.02
413007	.05	.01	.01	.04
413006	.03	.03	.02	.03
413005	.01	.01	.08	.04
413010		.03		.03
413615	.02	.03		.03
413625	.02	3.59		2.21
413034	.01	.02		.02
683089	.01	.04	.12	.07

Table I-A-19. Seasonal mean concentrations (mg/L), standard deviations, and frequency of sampling for chlorides during 1979 baseflow

STORET NUMBER	SPR 79	SUM 79	FALL 79	ALL SEASONS
		Frequency		
463001	6.	5.	2.	13.
413011	7.	3.	2.	12.
413007	7.	5.	2.	14.
413006	6.	6.	2.	14.
413005	5.	4.	2.	11.
		Mean concentration		
463001	40.17	29.40	32.00	34.77
413011	294.71	220.00	130.00	248.58
413007	196.57	201.00	132.50	189.00
413006	314.83	138.00	102.50	208.71
413005	133.00	150.00	160.00	144.09
		Standard deviation		
463001	1.47	5.55	1.41	6.26
413011	121.81	13.23	0.00	110.72
413007	88.70	79.09	24.75	78.61
413006	86.94	27.93	17.68	111.68
413005	18.23	24.49	.00	20.95

Table I-A-20. Seasonal mean concentrations (mg/L), standard deviations, and frequency of sampling for chlorides during 1979 events

STORET NUMBER	SPR 79	SUM 79	FALL 79	ALL SEASONS
		Frequency		
463001	37.	10.	19.	66.
413011	39.	43.	38.	120.
413007	52.	18.	6.	76.
413006	56.	25.	19.	100.
413005	33.	45.	32.	110.
413010		46.		46.
413615	28.	43.		71.
413625	58.	29.		87.
413034	24.	28.		52.
683089	36.	40.	32.	108.
		Mean concentration		
463001	34.70	30.80	36.16	34.53
413011	105.95	80.60	73.00	86.43
413007	115.04	47.39	51.17	93.97
413006	210.95	45.92	25.89	134.53
413005	141.06	88.64	109.53	110.45
413010		16.04		16.04
413615	329.39	83.42		180.42
413625	63.83	46.45		58.03
413034	21.00	13.00		16.69
683089	225.72	60.35	25.97	105.29
		Standard deviation		
463001	7.73	4.66	6.73	7.18
413011	60.88	49.92	44.92	53.71
413007	43.46	24.59	6.15	48.98
413006	214.51	36.18	16.49	182.98
413005	120.86	21.85	43.90	74.22
413010		15.99		15.99
413615	236.93	132.03		216.26
413625	31.87	34.90		33.73
413034	17.04	9.68		14.03
683089	295.55	87.86	50.06	199.07

Table I-A-21. Seasonal mean concentrations (ug/L), standard deviations, and frequency of sampling for lead during 1979 events and baseflow

STORET NUMBER	SPR 79	SUM 79	FALL 79	ALL SEASONS
		EVENT SAMPLES		
		Frequency		
413005	34.	38.	31.	103.
		Mean concentration		
413005	76.71	61.92	48.27	62.69
		Standard Deviation		
413005	147.57	52.73	38.09	92.79
		BASEFLOW SAMPLES		
		Frequency		
413005	4.	3.	1.	8.
		Mean concentration		
413005	.23	.10	.10	.16
		Standard deviation		
413005	.25	.00	.00	.18

Table I-A-22. Seasonal mean concentrations (ug/L), standard deviations, and frequency of sampling for cadmium during 1979 events and baseflow

STORET NUMBER	SPR 79	SUM 79	FALL 79	ALL SEASONS
		EVENT SAMPLES		
		Frequency		
413005	34.	38.	32.	104.
		Mean concentration		
413005	.84	.52	.32	.52
		Standard Deviation		
413005	1.50	.61	.39	.99
		BASEFLOW SAMPLES		
		Frequency		
413005	4.	3.	1.	8.
		Mean concentration		
413005	.23	.10	.10	.16
		Standard deviation		
413005	.25	.00	.00	.18

Table I-A-23. Bacterial counts in baseflow samples collected during the spring and fall of 1978*

Station**	Bacteria Counts (X100)						
	Fecal Coliform (FC)			Fecal Streptococcus (FS)		FC/FS Ratio	
	3/29	5/2	11/1	5/2	11/1	5/2	11/1
1			32		1.0		32
2			0.1		0.2		0.5
5			0.6		0.4		1.5
6			0.7		0.2		3.5
8		1.2		1.7		0.7	
9		52	38	1.2	5.6	43	6.8
10		400		300		1.3	
11		4.4		1.7		2.6	
12		0.1		0.1		1.0	
13		78		6.0		13	
16		1.3	50	0.2	6.0	6.5	8.3
17	2.5		3.3		0.5		6.6
673001			0.1		0.1		1.0
463001	1.1						
413008		0.4	0.7	0.2	0.1	2	7
413005	15	19	12	1.0	1.0	19	12
683002			5.0		7.0		7.1
683001		14	2.7	1.3	0.4	11	6.8
413011	0.1						
413007	0.1						
413010	0.1						
413006	1.0	2.7	9.0	0.3	2.1	9	4.3
413009		400		200		2	

* Fecal coliform corresponds to MFFCC/100 ml and FS are in counts/100 ml.

** Station descriptions in Table I-26-A.

Table I-A-24. Bacterial counts in event samples collected during the spring of 1978*

Station**	Bacteria Counts (X1000)							
	Fecal Coliform (FC)				Fecal Streptococcus (FS)		FC/FS Ratio	
	4/6	4/18	5/12	5/15	5/12	5/15	5/12	5/15
1				2.4		0.4		6.0
2				1.0		0.2		0.2
3			0.7		1.8		0.4	
4				1.5		0.9		1.7
5				0.6		0.3		2.0
8			3.4		3.8		0.9	
9			3.3		6.3		0.5	
10			100		100		1.0	
11			0.4		1.0		0.4	
12			0.1		0.1		1.0	
13			2.9		4.4		0.6	
14				6.2		3.9		1.6
16			6.1		2.0		3.0	
17				40				
673001				2.0		0.6		3.3
463001	3.2	0.2						
413008			3.4		3.2		1.1	
413005	20	4.5	3.6		2.0		1.5	
413009			100.0		80		1.2	
683002				4.0		1.4		2.8
683001			1.7		0.8		2.1	
413011	0.9	1.0						
413001	1.8	1.2						
413010	0.9	2.6						
413006	40	2.1	3.1		2.0		1.5	

* Fecal coliform corresponds to MFFCC/100 ml and FS are in counts/100 ml.
** Station descriptions in Table I-2.

Table I-A-25. Bacterial counts in event samples collected during the summer of 1978*

Station**	Bacteria Counts (X1000)											
	Fecal Coliform (FC)				Fecal Streptococcus (FS)				FC/FS Ratio			
	7/20	8/18	9/13	9/14	7/20	8/18	9/13	9/14	7/20	8/18	9/13	9/14
1	30	100	25		1.0	100	6.0		30	1.0	4.1	
2	0.5	1.8	12		1.7	4.5	10		0.3	0.4	1.2	
3	5.5		3.2		11		21		0.5		0.2	
4	0.2				0.3				0.7			
5	0.6				1.6				0.4			
6		22		35		36		37	0.6			0.9
7			7.5				6.5				1.2	
8		25				17				1.5		
9			11				23				0.3	
11			4.7				2.0				2.3	
15		16		11		0.6		1.9		27		0.4
16			20				15				1.3	
17		18		250		2.8		41		6.4		6.0
673001		0.5		1.5		0.2		0.5		2.5		3.0
413008			20				36				0.5	
413005		30				65				0.5		
463001			10				38				0.3	
413006		100				80				1.2		

* Fecal coliform corresponds to MFFCC/100 ml and FS are in counts/100 ml.
** Station descriptions in Table I-2.

Table I-A-26. Flows (cms) and pollutant concentrations (mg/L) at 413005 for selected event and baseflow samples collected in 1978

Baseflow Sampling Dates	Event Times: Start and Stop	Event Times: Samples Date	Event Times: Samples Time	Flows	Suspended Solids	Total P	Soluble P	Chloride
780329				6.3	20	.12	.048	140
	7804052100							
		780406	0515	22.8	368	.53	.045	120
			0915	21.1	262	.44	.065	150
			1315	41.3	452	.64	.071	100
			1515	33.9	234	.37	.045	150
			1715	29.0	256	.49	.090	120
		780407	0900	18.3	94	.18	.048	100
	7804090100							
780523				2.2	4	.09	.023	135
	7806160200							
		780616	0300	3.6	308	.52	.071	165
			1200	11.9	200	.37	.035	45
			2100	5.0	176	.37	.067	95
		780617	0600	26.0	328	.44	.029	32
			1500	33.6	390	.44	.046	38
			2000	30.2	338	.44	.063	36
			2359	28.9	230	.44	.089	32
		780618	0900	31.9	95	.31	.095	34
			1800	21.0	64	.24	.096	46
		780619	1200	13.3	142	.24	.048	43
		780620	0500	10.6	138	.23	.088	63
			2300	8.9	136	.20	.068	54
	7806210200							
780628				1.6	9	.24	.114	110
	7806300900							
		780701	0210	7.2	468	.20	.038	50
			2110	15.5	115	.23	.073	57
		780702	1710	38.6	314	.20	.063	24
		780703	1310	27.1	151	.30	.095	32
	7807072100							
780928				1.2	11	.13	.067	135

Table I-A-27. Flows (cms) and pollutant concentrations (mg/L) at 413005 for selected events and baseflow samples collected in the spring of 1979

Baseflow Sampling Dates	Event Times: Start and Stop	Samples: Date	Samples: Time	Flows	Suspended Solids	Total P	Soluble P	Chloride	Total* Lead
	7903160800	790316	1740	11.0	150	.10	.016	128	14
		790317	0140	10.4	131	.11	.020	120	12
			0940	8.7	178	.10	.021	112	9
			1740	12.2	175	.12	.018	145	38
		790318	0140	12.5	164	.12	.026	120	18
			0940	13.2	157	.11	.021	100	12
			1740	30.0	335	.20	.027	90	37
		790319	0140	48.4	134	.14	.022	95	18
			0940	52.1	168	.42	.046	75	20
			1740	53.5	150	.20	.042	70	10
	7903201300	790320	0140	46.8	102	.17	.036	58	12
790328				7.6	140	.10	.021	130	2
	7903281500	790329	2130	16.7	162	.10	.017	145	16
		790330	0530	25.7	179	.10	.019	140	10
			0550	25.1	400	.27	.021	120	180
			1310	41.7	250	.16	.015	100	55
			1330	42.6	173	.12	.016	135	86
			2110	42.3	368	.29	.026	68	55
			2130	42.3	190	.12	.022	115	27
		790331	0510	37.8	310	.23	.019	72	80
	7904011800		1310	26.6	241	.24	.020	60	19
790411				3.4	198	.08	.017	140	2
790502				5.8	99	.06	.016	105	2
	7905022100								
		790503	0040	12.0	154	.09	.012	85	12
			0440	13.3	140	.10	.015	80	10
			0840	11.5	120	.11	.018	92	4
			1240	9.7	102	.07	.012	88	2
			1640	8.7	124	.06	.011	95	2
			2040	8.2	117	.08	.008	90	4
	7905051600								
790522				1.4	173	.09	.008	135	2

*ug/l

Table I-A-28. Flows (cms) and pollutants concentrations (mg/L) at 413005 for selected events and baseflow samples collected in the summer of 1979

Baseflow Sampling Dates	Event Times: Start and Stop	Samples: Date	Samples: Time	Flows	Suspended Solids	Total P	Soluble P	Chloride	Total* Lead
790719				.5	51	.09	.022	160	6
	7907220700	790724	2155	6.2	250	.41	.056	90	220
			2355	5.2	198	.36	.043	75	159
		790725	0155	2.4	109	.24	.032	80	61
			0355	1.8	69	.22	.026	85	41
			0555	1.3	57	.20	.024	85	34
	7907260400		0755	1.8	68	.23	.040	85	38
	7908080500	790808	0720	3.9	143	.22	.054	110	81
			0920	3.8	81	.16	.046	108	44
			1120	2.2	79	.14	.044	90	36
			1320	1.5	65	.12	.041	88	29
			1520	1.2	64	.12	.031	82	21
			1720	1.0	54	.12	.035	90	id
		790809	1910	1.6	69	.15	.036	105	34
			1110	2.5	86	.18	.036	95	44
			1310	2.4	87	.18	.033	95	44
			1510	1.9	72	.16	.031	95	34
			1710	1.5	62	.14	.032	95	25
			1910	1.2	58	.14	.030	100	23
	7908112200		2190	1.1	47	.13	.033	100	20
790815				.6	72	.16	.040	130	5
	7908170200	790822	1855	14.3	79	.14	.043	68	id
			2055	19.1	97	.17	.027	70	id
			2255	10.2	188	.28	.035	52	id
		790823	0055	10.4	220	.20	.035	45	id
			0255	8.1	115	.20	.044	46	id
	7908251700		0455	7.2	97	.16	.037	46	id

id insufficient data
*ug/l

Table I-A-29. 1978 Seasonal and annual total and event unit area water loadings

STORET NUMBER	Season	Total Water $M^3 \times 1000$	% Event	Event Unit Load M^3/ha
463001	Spring	2,002	20	189
	Summer	1,849	47	403
	Fall	414	5	10
	Annual	4,265	30	602
413011	Spring	692	62	771
	Summer	1,024	93	1,727
	Fall	340	22	135
	Annual	2,056	71	2,633
413007	Spring	4,071	47	389
	Summer	4,039	50	405
	Fall	1,254	24	60
	Annual	9,365	45	854
413006	Spring	3,143	69	780
	Summer	4,012	72	1,033
	Fall	1,023	37	134
	Annual	8,179	66	1,947
413005	Spring	44,993	21	294
	Summer	38,960	51	613
	Fall	9,066	25	70
	Annual	92,909	34	978
413010	Spring	174	70	599
	Summer	209	67	696
	Fall	Id	Id	Id
	Annual	383*	68	1,295
413615	Spring	128	100	1,997
	Summer	86	100	1,350
	Fall	10	100	153
	Annual	224	100	3,500
413625	Spring	25	100	110
	Summer	69	100	308
	Fall	7	100	32
	Annual	101	100	450
413034	Spring	Id	Id	Id
	Summer	51	100	462
	Fall	1	100	10
	Annual	52*	100	472*
683089	Spring	68	100	1,113
	Summer	90	100	1,482
	Fall	13	100	214
	Annual	171	100	2,809

Id Data insufficient for determination of loading.

* Annual loadings estimated from only two seasons - o [illegible] on is missing flow values.

Table I-A-30. 1978 Seasonal and annual total and event unit area loadings and flow-weighted concentrations of suspended solids

STORET NUMBER	Season	Total Load kg x 1000	% Event	Unit Event Load (CI) kg/ha		Mean Event Conc. mg/L
463001	Spring	198.9	97	89.7	(141.4)+	474.9
	Summer	464.6	81	174.8	(193.5)	433.9
	Fall	id	id	id	(.0)	id
	Annual	663.5	86	264.6	(207.6)*	447.0
413011	Spring	156.6	100	281.8	(306.3)	365.6
	Summer	43.1	89	69.6	(54.1)	40.3
	Fall	id	id	id	(.0)	id
	Annual	293.7*	97	515.1	(309.6)*	140.7
413007	Spring	615.3	99	121.8	(137.9)	313.3
	Summer	931.6	90	168.8	(591.3)	416.8
	Fall	id	id	id	(.0)	id
	Annual	2,019.9*	93	377.7	(589.9)*	366.1
413006	Spring	1,029.0	93	343.9	(270.2)	441.0
	Summer	688.1	94	231.1	(191.9)	223.8
	Fall	612.3	91	200.9	(6.2)	1,499.6
	Annual	2,330.3	93	776.1	(356.9)	398.6
413005	Spring	10,358.0	31	99.3	(181.9)	338.0
	Summer	5,856.3	92	166.7	(48.7)	271.9
	Fall	4,336.1	84	113.6	(20.0)	1,624.0
	Annual	20,551.1	60	379.7	(198.4)	388.7
413010	Spring	108.3	73	392.1	(143.8)	654.6
	Summer	55.8	53	146.0	(83.7)	209.7
	Fall	id	id	id	(.0)	id
	Annual	165.2**	66	538.1	(172.1)**	415.5
413615	Spring	72.2	100	1,127.5	(630.6)	564.6
	Summer	19.6	100	305.5	(54.7)	226.3
	Fall	.9	100	13.5	(8.6)	88.5
	Annual	92.6	100	1,446.6	(651.8)	413.3
413625	Spring	21.7	100	97.0	(71.4)	882.1
	Summer	28.4	100	126.8	(67.5)	411.8
	Fall	1.1	100	5.0	(1.8)	158.7
	Annual	51.3	100	228.9	(87.8)	508.8
413034	Spring	id	id	id	(.0)	id
	Summer	3.7	100	33.8	(26.8)	73.2
	Fall	.1	100	.7	(.3)	77.6
	Annual	3.8**	100	34.6	(28.0)**	73.3
683089	Spring	23.1	100	379.4	(654.5)	340.9
	Summer	14.1	100	231.3	(166.1)	156.1
	Fall	3.7	100	60.6	(42.8)	283.3
	Annual	41.0	100	671.4	(476.7)	239.0

id Data insufficient for determination of loading.
* Annual load estimated using summer and spring concentrations applied to spring, summer and fall flows.
** Annual loadings estimated from two seasons - one season is missing flow values.
\+ 95% confidence interval.

Table I-A-31. 1978 Seasonal and annual total and event unit area loadings and flow-weighted concentrations of Total-P

STORET NUMBER	Season	Total Load kg	% Event	Unit Event Load (CI) kg/ha	Mean Event Conc. mg/L
463001	Spring	460.3	83	.17 (.19)+	.93
	Summer	846.3	88	.34 (.26)	.85
	Fall	id	id	id (.00)	id
	Annual	1,861.1*	86	.74 (.28)*	.88
413011	Spring	170.5	95	.29 (.17)	.37
	Summer	122.7	96	.21 (.03)	.12
	Fall	id	id	id (.00)	id
	Annual	415.1*	95	.71 (.17)*	.20
413007	Spring	966.2	88	.17 (.15)	.45
	Summer	937.9	87	.16 (.39)	.40
	Fall	id	id	id (.00)	id
	Annual	2,525.8*	88	.44 (.40)*	.42
413006	Spring	1,655.4	80	.47 (.38)	.61
	Summer	1054.0	90	.34 (.34)	.32
	Fall	989.1	80	.28 (.20)	2.11
	Annual	3,698.5	83	1.10 (.53)	.56
413005	Spring	16,953.0	25	.13 (.16)	.45
	Summer	9,905.9	67	.20 (.03)	.33
	Fall	2,376.8	60	.04 (.03)	.63
	Annual	29,235.7	42	.38 (.19)	.39
413010	Spring	181.8	70	.62 (.39)	1.04
	Summer	73.3	96	.34 (.18)	.50
	Fall	id	id	id (.00)	id
	Annual	255.2**	77	.97 (.38)**	.75
413615	Spring	66.8	100	1.04 (.33)	.52
	Summer	33.5	100	.52 (.11)	.38
	Fall	1.9	99	.02 (.01)	.19
	Annual	102.1	100	1.59 (.34)	.45
413625	Spring	17.8	100	.07 (.36)	.72
	Summer	27.4	100	.12 (.03)	.39
	Fall	1.9	99	.00 (.00)	.26
	Annual	47.0	100	.21 (.48)	.46
413034	Spring	id	id	id (.00)	id
	Summer	10.7	100	.09 (.07)	2.02
	Fall	.2	95	.00 (.00)	.18
	Annual	10.9**	100	.09 (.05)**	1.70
683089	Spring	28.9	100	.47 (.63)	.42
	Summer	16.0	100	.26 (.12)	.17
	Fall	2.3	100	.04 (.01)	.17
	Annual	47.2	100	.77 (.46)	.27

id Data insufficient for determination of loading.
* Annual load estimated using summer and spring concentrations applied to spring, summer and fall flows.
** Annual loading estimated from two seasons - one season is missing flow values.
\+ 95% confidence interval.

Table I-A-32. 1978 Seasonal and annual total and event unit area loadings and flow-weighted concentrations of Soluble-P

STORET NUMBER	Season	Total Load kg	% Event	Unit Event Load (CI) kg/ha	Mean Event Conc. mg/l
463001	Spring	117.4	74	.041 (.020)+	.214
	Summer	316.3	89	.131 (.126)	.325
	Fall	id	id	id (.000)	id
	Annual	645.2*	85	.259 (.127)*	.290
413011	Spring	17.1	94	.029 (.016)	.038
	Summer	37.2	96	.065 (.028)	.038
	Fall	id	id	id (.000)	id
	Annual	72.7*	96	.126 (.027)*	.038
413007	Spring	117.0	90	.021 (.017)	.054
	Summer	121.6	81	.020 (.021)	.049
	Fall	id	id	id (.000)	id
	Annual	325.3*	85	.056 (.025)*	.052
413006	Spring	397.0	67	.095 (.087)	.122
	Summer	127.9	77	.036 (.025)	.034
	Fall	267.7	70	.067 (.015)	.500
	Annual	792.5	70	.198 (.110)	.102
413005	Spring	2,147.1	56	.037 (.090)	.126
	Summer	2,703.2	44	.037 (.012)	.060
	Fall	709.7	65	.014 (.010)	.203
	Annual	5,560.1	51	.088 (.034)	.090
413010	Spring	35.3	96	.168 (.046)	.281
	Summer	9.3	100	.046 (.054)	.066
	Fall	id	id	id (.000)	id
	Annual	44.6**	97	.214 (.056)**	.166
413615	Spring	4.5	100	.069 (.043)	.035
	Summer	3.1	100	.048 (.020)	.036
	Fall	.3	97	.005 (.004)	.031
	Annual	7.9	100	.122 (.048)	.035
413625	Spring	1.3	99	.069 (.001)	.053
	Summer	4.5	100	.020 (.008)	.065
	Fall	.7	98	.003 (.002)	.091
	Annual	6.5	100	.029 (.011)	.064
413034	Spring	id	id	id (.000)	id
	Summer	4.0	100	.037 (.031)	.079
	Fall	.0	75	.000 (.000)	.028
	Annual	4.1**	99	.037 (.024)**	.078
683089	Spring	5.2	100	.085 (.050)	.076
	Summer	3.4	100	.056 (.017)	.038
	Fall	.4	98	.007 (.005)	.032
	Annual	9.0	100	.148 (.060)	.053

id Data insufficient for determination of loading.
* Annual load estimated using summer and spring concentrations applied to spring, summer and fall flows.
** Annual loading estimated from two seasons - one season is missing flow values.
\+ 95% confidence interval.

Table I-A-33. 1979 Seasonal and annual total and event unit area water loadings

STORET NUMBER	Season	Total Water $M^3 \times 1000$	% Event	Event Unit Load M^3/ha
463001	Spring	4,891	30	687
	Summer	312	8	12
	Fall	162	3	3
	Annual	5,365	28	702
413011	Spring	1,061	55	1,054
	Summer	468	72	611
	Fall	121	78	170
	Annual	1,650	62	1,836
413007	Spring	9,704	30	581
	Summer	2,629	26	136
	Fall	1,101	31	69
	Annual	13,434	29	786
413006	Spring	5,952	57	1,216
	Summer	2,052	32	238
	Fall	910	54	175
	Annual	8,914	51	1,630
413005	Spring	75,218	16	376
	Summer	13,532	39	165
	Fall	6,078	31	58
	Annual	94,828	20	599
413010	Spring	253	22	277
	Summer	151	63	471
	Fall	310	2	32
	Annual	714	22	781
413615	Spring	113	100	1,764
	Summer	54	100	837
	Fall	10	100	156
	Annual	176	100	2,757
413625	Spring	250	100	1,118
	Summer	16	100	73
	Fall	4	100	19
	Annual	271	100	1,210
413034	Spring	30	100	269
	Summer	15	100	133
	Fall	13	100	122
	Annual	58	100	524
683089	Spring	51	100	829
	Summer	45	100	731
	Fall	16	100	265
	Annual	111	100	1,825

Table I-A-34. 1979 Seasonal and annual total and event unit area loadings and flow-weighted concentrations of suspended solids

STORET NUMBER	Season	Total Load kg x 1000	% Event	Unit Event Load (CI) kg/ha	Mean Event Conc. mg/L
463001	Spring	650.6	24	74.3 (31.1)+	108.1
	Summer	40.4	11	2.1 (3.7)	176.0
	Fall	20.1	1	.1 (.0)	41.7
	Annual	711.1	23	76.5 (37.3)	109.0
413011	Spring	226.3	74	302.7 (168.3)	287.2
	Summer	74.2	88	118.6 (95.3)	194.1
	Fall	15.0	83	22.6 (12.8)	133.0
	Annual	315.6	78	444.0 (177.8)	241.9
413007	Spring	1,695.2	52	178.5 (44.4)	307.2
	Summer	361.6	57	41.4 (28.0)	304.7
	Fall	84.5	19	3.1 (6.7)	45.8
	Annual	2,141.3	52	223.1 (69.0)	283.8
413006	Spring	1,243.3	73	326.6 (242.7)	268.6
	Summer	283.6	64	65.4 (36.5)	274.9
	Fall	238.5	87	74.8 (46.0)	427.8
	Annual	1,765.3	74	466.9 (246.2)	286.6
413005	Spring	12,325.7	26	100.7 (34.2)	267.8
	Summer	1,542.4	67	32.0 (10.6)	194.2
	Fall	476.4	44	6.4 (17.8)	111.1
	Annual	14,344.5	31	139.2 (40.4	232.4
413010	Spring	Id	Id	Id (.0)	Id
	Summer	28.2	100	139.5 (53.6)	296.1
	Fall	Id	Id	Id (.0)	Id
	Annual	57.5*	100	284.6 (78.0)*	296.1
413615	Spring	26.4	100	412.6 (192.8)	233.9
	Summer	10.4	100	162.1 (42.9)	193.7
	Fall	Id	Id	Id (.0)	Id
	Annual	40.0*	100	625.0 (219.2)*	221.0
413625	Spring	249.1	100	1,111.8 (444.7)	994.5
	Summer	5.0	100	22.4 (8.2)	307.7
	Fall	Id	Id	Id (.0)	Id
	Annual	260.0*	100	1,160.7 (446.5)*	952.4
413034	Spring	5.5	100	49.8 (57.9)	185.2
	Summer	9.0	100	81.9 (93,0)	616.4
	Fall	Id	Id	Id (.0)	Id
	Annual	17.6*	100	160.0 (128.4)*	327.9
683089	Spring	9.2	100	151.1 (77.0)	182.2
	Summer	11.1	100	181.6 (48.5)	248.5
	Fall	.8	100	12.9 (5.0)	48.9
	Annual	21.1	100	345.7 (95.3)	189.4

Id Data insufficient for determination of loading.

* Annual load estimated using summer and spring concentrations applied to spring, summer and fall flows.

\+ 95% confidence interval.

Table I-A-35. 1979 Seasonal and annual total and event unit area loadings and flow-weighted concentrations of Total-P

STORET NUMBER	Season	Total Load kg	% Event	Unit Event Load (CI) kg/ha	Mean Event Conc. mg/L
463001	Spring	915.5	66	.28 (.03)+	.41
	Summer	44.6	43	.01 (.00)	.74
	Fall	11.2	14	.00 (.00)	.25
	Annual	971.4	65	.29 (.04)	.42
413011	Spring	153.5	91	.25 (.07)	.24
	Summer	78.4	93	.13 (.03)	.21
	Fall	22.1	94	.03 (.01)	.22
	Annual	254.0	92	.42 (.08)	.23
413007	Spring	1,810.6	64	.23 (.03)	.40
	Summer	455.0	75	.06 (.02)	.50
	Fall	105.8	62	.01 (.01)	.19
	Annual	2,371.4	66	.31 (.06)	.40
413006	Spring	1,192.8	81	.34 (.08)	.28
	Summer	466.8	80	.13 (.06)	.56
	Fall	244.1	95	.08 (.03)	.47
	Annual	1,903.6	82	.56 (.11)	.34
413005	Spring	9,094.7	40	.11 (.03)	.30
	Summer	2,449.5	57	.04 (.01)	.26
	Fall	841.8	64	.01 (.00)	.28
	Annual	12,386.0	45	.17 (.03)	.29
413010	Spring	Id	Id	Id (.00)	Id
	Summer	33.8	100	.16 (.06)	.35
	Fall	Id	Id	Id (.00)	Id
	Annual	84.7*	100	.41 (.09)*	.35
413615	Spring	27.0	100	.42 (.10)	.23
	Summer	14.8	100	.23 (.04)	.27
	Fall	Id	Id	Id (.00)	Id
	Annual	45.3*	100	.70 (.13)*	.25
413625	Spring	136.7	100	.61 (.16)	.54
	Summer	39.6	100	.17 (.14)	2.42
	Fall	Id	Id	Id (.00)	Id
	Annual	191.6*	100	.85 (.21)*	.66
413034	Spring	3.8	100	.03 (.03)	.13
	Summer	6.8	100	.06 (.04)	.46
	Fall	Id	Id	Id (.00)	Id
	Annual	13.6*	100	.12 (.06)*	.24
683089	Spring	6.2	100	.10 (.03)	.12
	Summer	11.3	100	.18 (.03)	.25
	Fall	2.2	100	.03 (.01)	.13
	Annual	19.8	100	.32 (.04)	.17

Id Data insufficient for determination of loading.
* Annual load estimated using summer and spring concentrations applied to spring, summer and fall flows.
\+ 95% confidence interval.

Table I-A-36. 1979 Seasonal and annual total and event unit area loadings and flow-weighted concentrations of Soluble-P

STORET NUMBER	Season	Total Load kg	% Event	Unit Event Load (CI) kg/ha	Mean Event Conc. mg/L
463001	Spring	370.8	83	.14 (.02)+	.20
	Summer	10.2	50	.00 (.00)	.19
	Fall	1.7	19	.00 (.00)	.05
	Annual	382.8	82	.14 (.02)	.20
413011	Spring	20.6	54	.02 (.01)	.01
	Summer	12.1	98	.02 (.00)	.03
	Fall	5.0	98	.00 (.00)	.05
	Annual	37.6	74	.05 (.01)	.02
413007	Spring	377.0	72	.05 (.01)	.09
	Summer	69.9	79	.01 (.00)	.08
	Fall	19.1	74	.00 (.00)	.04
	Annual	466.0	73	.06 (.02)	.08
413006	Spring	334.4	84	.10 (.03)	.08
	Summer	64.6	73	.01 (.00)	.07
	Fall	16.6	92	.00 (.00)	.03
	Annual	415.6	83	.12 (.03)	.07
413005	Spring	1,481.3	22	.01 (.00)	.02
	Summer	480.3	46	.00 (.00)	.04
	Fall	153.9	81	.00 (.00)	.06
	Annual	2,115.5	32	.02 (.00)	.03
413010	Spring	id	id	id (.00)	id
	Summer	5.5	100	.02 (.01)	.05
	Fall	id	id	id (.00)	id
	Annual	18.8*	100	.09 (.02)*	.05
413615	Spring	5.7	100	.08 (.03)	.05
	Summer	1.6	100	.02 (.00)	.03
	Fall	id	id	id (.00)	id
	Annual	7.5*	100	.11 (.03)*	.04
413625	Spring	10.5	100	.04 (.00)	.04
	Summer	24.0	100	.10 (.09)	1.46
	Fall	id	id	id (.00)	id
	Annual	43.6*	100	.19 (.09)*	.12
413034	Spring	.9	100	.00 (.01)	.02
	Summer	.5	100	.00 (.00)	.03
	Fall	id	id	id (.00)	id
	Annual	1.6*	99	.01 (.01)*	.03
683089	Spring	.7	100	.01 (.00)	.01
	Summer	.9	100	.01 (.00)	.02
	Fall	.8	100	.01 (.00)	.04
	Annual	2.4	100	.04 (.00)	.02

id Data insufficient for determination of loading.

* Annual load estimated using summer and spring concentrations applied to spring, summer and fall flows.

\+ 95% confidence interval.

Table I-A-37. 1979 Seasonal and annual total and event unit area water and pollutant loadings at 413616

Category	Spring	Summer	Fall	Annual
		Water		
Total loading, M^3 x 100	31	148	5	184
% Event	100	100	100	100
Event loading, M^3/ha	623	3,021	111	3,755
		Suspended Solids		
Total loading kg x 1000	1.5	12.6	0.1	14.2
% Event	100	100	100	100
Event loading, kg/ha	30(22)	256(55)	3(1)	289(54)
Mean concentration, mg/L	49	84	25	77
		Total P		
Total loading, kg	15	35	2	51
% Event	100	100	99	100
Event loading, kg/ha	0.3(0.17)	0.71(0.22)	0.04(0.00)	1.05(0.24)
Mean concentration, mg/L	0.50	0.23	0.32	0.28
		Soluble P		
Total loading, kg	5	13	1	19
% Event	100	100	99	100
Event loading, kg/ha	0.11(0.05)	0.26(0.10)	0.02(0.00)	0.39(0.11)
Mean concentration, mg/L	0.18	0.08	0.14	0.10

( )95% confidence internal.

Part II

SUMMARY AND ANALYSIS OF SURFACE WATER QUALITY FROM 1975 TO 1979

By

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Abstract

The quality of runoff from three mixed (mainstem) and six predominantly single land use sites was monitored between 1975 and 1979 using automatic flow recording and water sampling equipment. Six of the sites were monitored for five years and the others for four years. Suspended solids, total-P, soluble-P and chloride were monitored throughout the study at all sites while lead and cadmium were measured for 4 years at the river mouth. Concentration data of all pollutants except chloride are summarized as mean seasonal flow weighted concentrations. Seasonal mean event pollutant concentration are generally higher than mean baseflow concentrations. The duration of event flows during a season is approximately equivalent to the duration of elevated pollutant concentrations in the Menomonee River system. The highest concentrations usually occur in the spring at stations with smaller drainage areas and occur most often in summer or fall at stations with the larger watersheds. Runoff from the agricultural watershed usually had the highest concentrations of suspended solids, total-P and soluble-P in summer; these pollutants also had high concentrations in spring.

Seasonal and annual event unit area loadings were estimated for water, suspended solids, total-P and soluble-P throughout the study using a stratified random sampling model enhanced by a ratio estimator. Lead event unit area loadings were estimated for 4 years at the river mouth. Summaries of the seasonal water and pollutant event unit area loadings are presented. Seasonal baseflow loadings are also summarized for sites with perennial streams. The high event loadings demonstrate the importance of nonpoint source pollution in the Menomonee River Watershed. The connected imperviousness was found to be the main hydrologic factor affecting the variation in loadings between drainage areas. The degree of connected imperviousness affects the amount of runoff and the transport of pollutants. Generally runoff and pollutant loading increase with greater connected imperviousness. Remedial measures should be oriented to those urban land uses (freeways, shopping centers, and developing areas), which because of their high amounts of connected imperviousness and pollutants available for wash-off, generate large amounts of runoff and high pollutant concentrations. Similarities of total-P and suspended solids event unit area loadings between urban drainage areas in the Menomonee River Watershed and agricultural watersheds in different parts of Wisconsin, suggest the importance of remedial measures in any watershed with a significant amount of urbanization.

Rainfall was found to be the major meteorological factor affecting variations in seasonal event unit area loadings from year to year at a given station. The effect of rainfall on loading was increased in a spring with an extended period of frozen ground.

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TABLES

II-1. INTRODUCTION

The purpose of Part II is to summarize and analyze the surface water quality data collected at nine sites in the Menomonee River Watershed between 1975 and 1979. The nine sites were chosen for continued monitoring in 1978 and 1979 and were included in the 19 sites sampled between 1975 and 1977. The monitoring results from 1975 to 1977 and the data collected in 1978 and 1979 were documented in separate volumes: Volume 3 (1) and Part I of Reference Volume 12(2), respectively. The monitoring was continued in 1978 and 1979 to enhance the assessment in Volume 3 of the quality and quantity of runoff from mixed and predominantly single land use areas. In Part II, the five years of data are consolidated and analyzed to define more precisely the variability of seasonal concentrations and loadings from various land use sites. An analysis is presented of factors effecting differences in seasonal event unit area loadings between stations in a given season and between seasons at a given station.

II-2. CONCLUSIONS

Nonpoint source pollution is an important factor influencing stream water quality in the Menomonee River basin -- concentrations of pollutants are generally higher during runoff events than during baseflow. The average number of seasonal event days shows ranges in duration of elevated flow and concentration from approximately 10 to 50 days in spring, 10 to 30 days in summer and 10 to 20 days in fall for different subwatersheds. The average percentages of event days within a season at the river mouth are 49, 31 and 17 for spring, summer and fall, respectively. This indicates that elevated pollutant concentrations are present in the downstream segments of the Menomonee River for significant parts of spring, summer and fall.

Event unit area water and pollutant loadings for a given subwatershed varied among seasons in the same year and within the same seasons for different years. In general, spring seasonal loadings are higher than summer loadings with fall loadings being the lowest. Rainfall is the most important meterological factor affecting the differences in seasonal loadings. The inherent variability of rainfall and other meteorological conditions must be considered in the design and evaluation of nonpoint source management strategies.

The addition of 1978 and 1979 monitoring data to the analysis presented in Volume 3 (1) illustrates potential problems in attempts to characterize seasonal event loadings with only 1 or 2 years of monitoring data. For example, the conclusions for loadings from predominantly single land use sites presented in Volume 3 were derived from one year of monitoring in 1977 -- a year with an unusually dry spring and wet summer.

Event unit area loadings of water and pollutants varied among watersheds within a given season. The more urbanized subwatersheds generally have higher event unit area loadings. The percentage of impervious surfaces directly connected to the drainage system was found to be the most important hydrologic factor affecting the variability of event unit area loadings among the subwatersheds in the Menomonee River Watershed. Both the hydrologic factors affecting pollutant transport and the land use activities contributing to high concentrations of pollutants should be considered in the development of management strategies for urban areas. Perhaps the problem may be best addressed through the hydrologic factors affecting pollutant transport, i.e., by disconnecting impervious areas from the drainage system.

Unit area suspended solids and total-P loadings from urban subwatersheds in the Menomonee River Watershed were within the range of contributions from agricultural watersheds in southwestern Wisconsin. When considering the impact on a stream from adjacent land uses on a unit area basis, nonpoint source contributions from urban areas may be equal or greater in importance than those from agricultural areas depending upon the type of pollutant.

II-3. MATERIALS AND PROCEDURES

Study Sites

Between 1975 and 1979, a nonpoint source monitoring program was conducted at three sites for five years and six sites for four years in the Menomonee River Watershed. The nine sites included three mixed land use sites (mainstem stations) and six predominantly single land use sites. Another ten sites were also monitored between 1975 and 1977, but eight of these sites were not selected for continued monitoring or had a limited sampling program in 1978 and 1979. The other two stations were only monitored in 1978. The monitoring was continued at the nine sites to further assess the variability in the quality and quantity of stormwater in the Watershed. The three mainstem sites were chosen to characterize water quality from the Watershed as a whole (413005) and two of the tributaries (413006 and 413007). The sites were also selected to allow a comparison between drainage from mixed land uses and predominantly single land uses. The six predominantly single land use sites (413010, 683089, 413625, 413011, 413615, 463001) represent the major land uses in the Menomonee River Watershed.

Land use distributions adjacent to the nine monitoring sites is shown in Table I-1 of Part I, Volume 12(2). Other land use information has been summarized (3).

The location of the monitoring sites is displayed in Fig. I-1 of Part I, Volume 12(2). The sites are numbered according to the format used for the U.S. EPA STORET data base.

Sampling Equipment

The equipment originally installed at each station was used throughout the study. Three of the predominantly single land use sites (413625, 413615, and 683089) consisted of a control structure, stage recorder, stilling well, automatic water sampler and a small protective enclosure. Samples were collected either from an open ditch (413625) or a storm sewer pipe (413615 and 683089). An Instrument Specialties Company (ISCO) 1680 automatic water sampler was used to collect the samples and the stage height of the stilling well was recorded using a Stevens type A, model 71 stage recorder. A flow mode was used to collect samples in 1976 and 1977 and a time mode was selected to collect samples in 1978 and 1979. The sampling interval in the time mode was set after evaluating the event response at the sites for each season and ranged from 10 minutes to 2 hours. The samples were collected proportionate to flow rate in the flow mode.

Three mainstem river sites (413005, 413006, 413007) and three of the predominantly single land use sites (463001, 413011, 413010) consisted of water and flow sampling equipment housed in a 3x3 m stone or aluminum shelter that was supplied with electricity and heated in the winter. All the sites were located on perennial streams. The water samples were collected with a USGS PS-69 water sampler and the stage height of the stream was measured using a manometer manufactured by Scientific Instruments and recorded on a digital tape recorder (Fisher-Porter). The samples were usually collected at one hour time intervals. A more detailed description of the sampling equipment at all the sites is presented in Volume 3 (1) and Part I of Volume 12(2).

Sampling Procedures

The sampling procedures were generally the same throughout the study and emphasized samples collected during runoff events. The sampling procedure was designed to delineate the entire event hydrograph and its corresponding pollutograph. Sampling was initiated at stations 413005, 413006 and 413007 in 1975 and stations 413011, 413010, 463001, 413089, 413615 and 413625 were available for sampling in 1976. The event sampling dates for 1976 and 1977 are shown in Tables I-2, I-3 and II-3 of Volume 3 (1) and the events sampled in 1978 and 1979 are documented in Tables I-3 and I-4 of Volume 12(2). The magnitude of the events can be appreciated from the rain data presented in Volume 3 Part I(1) and Volume 12 Part I(2). Depending on the size of the event, five or more samples were selected for analysis; larger sample numbers were selected during the period of spring runoff. Selection was based on observation of the field-drawn hydrograph and samples were selected on the rising, peak and falling stages of the hydrograph. Actual time of sampling was recorded on the stage record. Samples were removed during the event or as quickly as possible after the event terminated.

For transport to the laboratory for analysis, the samples were placed in narrow mouth polypropylene bottles and mailed immediately. All samples were mailed in Styrofoam containers (4 samples each) fitted with an ice compartment. Periodic baseflow samples were collected from station numbers 463001, 413011, 413010, 413007, 413006 and 413005. The baseflow samples were collected by manually activating the automatic sampler.

The stage height was recorded continuously at all of the sites. The USGS was responsible for determining the flow values for all the sites with digital tapes. The strip charts were processed by the Wisconsin Water Resources Center, University of Wisconsin-Madison and the Wisconsin Department of Natural Resources. The flow values for all the sites were stored on computer tape and are available from the WDNR.

Laboratory Analysis

The summary and analysis of the water quality data from 1975 to 1979 focuses on key parameters in the Menomonee River Watershed. The key parameters were selected from the list of over 20 pollutants routinely monitored from 1975 to 1977. The pollutants deemed to be of greatest importance in the watershed are: suspended solids, total-P, lead and cadmium (1). The key parameters except cadmium were monitored throughout the study.

All the analyses were conducted at the Wisconsin State Hygiene Laboratory located at the University of Wisconsin, Madison, some 130 km from the sampling sites. The pollutants likely to undergo rapid transformation were processed upon arrival at the laboratory. Analytical procedures are described in Part I of Volume 12(2).

The data were filed in the STORET data base and in the WDNR computer mass storage files for reporting and statistical analysis.

Methods for Calculating Loading

A stratified random sampling model enhanced by a ratio estimator was used to estimate pollutant loading values at all the sites. The assumptions of the model are: 1) simple random sampling of water quality within the nonoverlapping subpopulations or strata is possible, and 2) supplemental flow information is available rather than instantaneous flow values taken only at those times the water quality samples were taken. The model produces load and variance estimates for each station and for the sum of the strata. The same model was used to estimate loads for 1975 to 1977 monitoring data. The calculations were performed using a computer program developed by the WDNR. The method is described in more detail in Volume 3(1).

II-4. RESULTS AND DISCUSSION

Flow and Concentration

Seasonal concentrations

Concentrations of suspended solids and total-P and soluble-P were monitored during runoff events at nine automatic stations, and during baseflow at those stations with perennial streams. Flow was recorded continuously at the automatic stations. Monitoring of flow and suspended solids concentrations began at three stations in 1975. Flow and concentrations of suspended solids, total-P and soluble-P were monitored at all nine stations in 1976 through 1979. Lead concentration was monitored at the river mouth in 1976 through 1979. Flow records were maintained on computer tape and are available from the WDNR. Concentration records were stored in the U.S. EPA STORET System. Mean daily and monthly flow values were tabulated for each station in the U.S. Geological Survey Water Data Reports for Wisconsin (4 to 8).

A summary of seasonal runoff event and baseflow mean flow-weighted pollutant concentrations is presented in Table II-1. Concentration data for other pollutants were obtained during the study and they are presented in Volume 3(1) and Volume 12 Part I(2). Seasons were defined as follows:

Summer - the period from June 1 to September 30 of each year.

Fall - the period from October 1 to December 21 of each year.

Winter - the period from December 22 to the onset of spring.

Spring - Initiated by observing the onset of sustained high flows and varied from year to year and between stations in a particular year.

Mean event pollutant concentrations were generally higher than mean non-event concentrations within a given station in spring, summer and fall for suspended solids and total-P and soluble-P. Mean concentrations of suspended solids and total-P were five and nine times greater, respectively, during events than during baseflow in any season. Soluble-P also showed a trend of elevated concentration during events, but variations between event and baseflow concentrations were generally small.

The highest seasonal mean flow-weighted concentrations of pollutants at a given station may occur in any season in a given year, but occurred most often in spring at those stations with smaller subwatersheds; 413011, 413010, 413615, 413625, and 683089, and in summer or fall at those stations with larger subwatersheds; 463001, 413007, 413006, and 413005.

Table II-1. Seasonal event and baseflow mean flow-weighted concentrations (mg/l) for 1976 to 1979

STORET	Spring		Summer		Fall	
Number	Event	Baseflow	Event	Baseflow	Event	Baseflow
			Suspended Solids			
463001	167	100+	578	101	161	127
413011	379	80+	274	67	99	96
413007	345	85+	468*	50*	191*	59**
413006	426	104*	365*	64*	468*	52*
413005	192	115*	360*	86*	520*	49*
413010	490		324		120	
413615	421		300		170	
413625	918		388		139	
683089	353		178		124	
			Total-P			
463001	.42	.08+	.95	.10+	.33	.06++
413011	.35	.03+	.28	.05+	.20	.05++
413007	.39	.09	.43	.07	.27	.09***
413006	.44	.47	.46	.12	.85	.36
413005	.36	.20	.47	.21	.45	.21
413010	.80		.51		.36	
413615	.40		.36		.25	
413625	.55		.75		.25	
683089	.32		.20		.15	
			Soluble-P			
463001	.14	.02+	.28	.03+	.00	.01++
413011	.05	.01+	.04	.01+	.06	.00++
413007	.05	.02	.05	.01	.07	.00+++
413006	.06	.05	.04	.03	.16	.07
413005	.08	.04	.05	.09	.11	.08
413010	.17		.06		.09	
413613	.04		.03		.03	
413625	.06		.31		.09	
683089	.04		.03		.04	
			Lead			
413005	.195+++		.387+++	.087++		

\+ 1979 and 1979 only
++ 1979 only
+++ 1976 and 1979 only

* 1975 thorugh 1979
** 1975, 1976, 1977, 1979 only
*** 1976, 1977, 1979 only

Examination of seasonal mean flow-weighted concentrations for individual years and for all years shows that the highest concentrations tended to occur at certain stations. During fall, the highest event mean flow-weighted concentrations of suspended solids, total-P and soluble-P were generally found at stations 413006 and 413005. Similiarly, the highest event mean flow-weighted concentrations of these pollutants were generally found at stations 463001 and 413625 during summer months, and at stations 413010 and 413006 during spring seasons.

Stations 413005 and 413006 generally had the highest seasonal baseflow mean flow-weighted concentrations of total-P and soluble-P during spring, summer and fall and suspended solids during spring. Station 463001, draining a predominantly agricultural watershed, generally had the highest baseflow mean flow-weighted suspended solids concentrations during summer and fall and had high suspended solids concentrations during spring as well.

Individual event flow and concentration

Tables II-A-1 and II-A-2 and Tables I-A-26 through I-A-28 of Part I, Volume 12(2) show flow and pollutant concentration data for selected baseflow periods and runoff events at station 413005. Concentrations of suspended solids, total-P and lead showed a positive relationship with flow during runoff events. Concentrations of these pollutants generally increased most rapidly at the onset of a runoff event, and the lowest concentrations were usually found during baseflow periods or toward the end of events. The relationship between flow and concentration of soluble-P appeared generally positive, but soluble-P concentrations tended to fluctuate with time during event periods.

Duration of elevated flow and concentration

Table II-A-3 shows the number of seasonal event days for different stations. The number of event days was computed by dividing the total number of hours of elevated flow during seasonal runoff events by 24. The duration of elevated flow for a runoff event depends upon precipitation magnitude and intensity, watershed area and other hydraulic factors such as connected imperviousness and soil infiltration capacity. Station 413005, with the largest watershed area, generally had the most runoff event days within a season, followed by 413006. Stations 413010 and 463001, located in tributaries, generally had the fewest runoff event days of those stations with both event flow and baseflow.

Except for 1977, spring runoff event days generally exceed the number of summer runoff event days. Table II-2, which shows the percent of runoff event days within seasons, further illustrates the longer duration in elevated flow occurring during spring. Fall usually had the least number of event days and the lowest seasonal percent event days. The number of event days for each season at different stations ranged from 10 to 50 days in spring, 10 to 30 days in summer and 10 to 20 days in fall.

Table II-2. Percent event days in each season for 1975 to 1979

Season	413005	413006	413007	463001	413011	413010	413615
				1975			
Spring	65	32	30	25	51	19	na*
Summer	44	25	19	20	17	6	na
Fall	21	22	16	9	27	9	na
				1976			
Spring	62	36	46	54	28	8	na
Summer	13	13	7	6	11	3	na
Fall	11	6	4	5	5	1	na
				1977			
Spring	25	25	20	13	20	5	na
Summer	39	27	22	16	25	5	na
Fall	11	10	7	5	11	2	na
				1978			
Spring	62	43	53	17	28	30	17
Summer	31	22	21	11	22	11	8
Fall	27	16	15	18	16	15	5
				1979			
Spring	32	40	26	26	36	35	22
Summer	30	26	19	10	25	13	5
Fall	16	13	14	11	32	8	10
				Average of Five Years			
Spring	49	35	35	27	33	19	id
Summer	31	23	18	13	20	8	id
Fall	17	13	11	10	18	7	id

* Not available.
id Insufficient data.

The seasonal duration of elevated concentrations of suspended solids, total-P and lead may be approximated by the duration of elevated flow during events. At station 413005, the percent event days of elevated flow and concentration ranged from 25 to 65 in spring, 13 to 44 in summer and 11 to 27 in fall, with seasonal averages of 49, 31 and 17, respectively. This indicates that elevated concentrations are present in the downstream segments of Menomonee River for significant parts of the spring, summer and fall.

Monitored Loading Data

Seasonal loadings

Seasonal water and pollutant loading estimates were computed for runoff events and baseflow when sufficient flow and concentration data were available. Water loadings were calculated by integration of flow values with time. Concentration and flow data were used to calculate pollutant loadings using a stratified random sampling model enhanced by a ratio estimator. This method is extensively explained in Section I-3, MATERIALS AND PROCEDURES, of Volume 3(1).

Runoff event loadings do not include baseflow loadings during event periods and thus, provide estimates of nonpoint source pollution from land uses within the Watershed. Seasonal total water and pollutant loadings for a station were obtained by adding seasonal runoff event and baseflow loadings.

Summaries of seasonal event unit area loadings of water, suspended solids, total-P and soluble-P and lead at all monitored stations for each year are presented in Tables II-A-4 through II-A-8. Seasonal event unit area water and pollutant loadings for stations 413005, 413006, 413011, 413615, and 683089 are also presented graphically in Figs. II-A-19 through II-A-38. Average seasonal and annual total water and pollutant loadings and percentage of total load attributed to runoff events for stations 413005, 413006, 413007 and 463001 are presented in Table II-3. The high percentage of event loadings compared with total loadings indicates the importance of nonpoint source pollution in the Watershed.

Event unit area water and pollutant loadings at a given station varied among seasons in the same year and in same season for different years. Event unit area loadings also varied among stations in a given season. Much of this variability can be explained by the connected imperviousness and the inherent seasonal and yearly variation in rainfall.

Table II-3. Average seasonal and annual total loadings of water and pollutants from 1975 to 1979 for all monitored seasons

STORET Number	Spring Total	Spring % Event*	Summer Total	Summer % Event	Fall Total	Fall % Event	Annual Total	Annual % Event
				Water ($m^3 \times 10^3$)				
413006	4,162	47	2,540	65	892	47	7,307	66
413005	52,475	42	20,580	44	16,059	13	79,202	36
413007	5,769	40	2,527	40	974	31	9,044	41
463001	3,735	25	1,080	41	288	5	7,365	19
				Suspended Solids ($Kg \times 10^3$)				
413006	1,317	89	608	95	233	91	2,053	90
413005	7,315	57	4,450	73	1,513	79	13,252	65
413007	1,035	71	571	72	95	64	1,771	78
463001	425	41	253	75	20	5	687	53
				Total P (Kg)				
413006	1,474	86	952	80	519	70	2,784	86
413005	13,324	53	6,509	64	2,230	43	21,569	52
413007	1,300	77	536	84	138	72	2,026	79
463001	733	67	445	85	11	18	1,417	79
				Soluble P (Kg)				
413006	216	78	98	86	98	57	430	72
413005	3,229	40	1,423	45	720	45	4,723	41
413007	173	57	67	75	10	90	275	72
463001	269	21	163	87	2	50	514	84

* Portion of total loading due to event.

Factors affecting loading

Pollutant loadings during runoff events are generally considered to come from nonpoint sources. Usually, in the Menomonee River Watershed, the majority (>60%) of total pollutant loadings were attributed to runoff events. However, generally > 50% of the stream water discharged was event runoff, as shown by averages of water loadings in Table II-3. The event water and pollutant loadings were a greater proportion of total loadings in the more urbanized subwatersheds than in the more rural subwatersheds. Pollutant loading is a product of two components -- the pollutant concentration and water volume.

Hydrologic factors affecting the volume of runoff water include snowmelt, rainfall quantity and intensity, slope, soil permeability, land cover, impervious area, and depression storage. The most important hydrologic factor affecting urban runoff is the area of impervious surfaces directly connected to the stream or drainage system. Most types of urban development in the Menomonee River Watershed have impervious areas directly connected to a subsurface storm sewer system which drains to a stream. The street surfaces and parking lots are usually about 90% connected and roof tops about 25% connected to a storm sewer. The result of connecting impervious areas to storm sewers or rivers is an increase in the amounts and intensity of runoff.

The concentration component is largely affected by the land use activities because land use determines the potential amount of material available for transport. Construction activities disturb vegetative covers and expose soils to erosion. Heavy traffic and air pollution in industrial, commercial and residential areas increase the accumulation of pollutants on impervious surfaces. The observed increases in concentrations of suspended solids, total-P and lead during events suggest that a source of these pollutants exists in the Watershed. Because of the multiple land uses in each tributary area, attempts to isolate the important sources of these pollutants is difficult. It is assumed that the largest sources of suspended solids in an urban area are construction sites while lead originates largely from vehicular emissions deposited in streets and parking lot surfaces.

Hydrologic factors affecting delivery of pollutants are important in controlling the concentrations of materials transported. Increasing the amount of runoff by any of the hydrologic factors will increase the transport of many of the pollutants. Large areas of connected impervious surfaces affect the transport of pollutants from urban areas by increasing scouring energy and velocity of overland flow. Thus, both the hydrologic factors affecting transport and the land use activities contributing to high concentrations of pollutants should be considered in the development of management strategies for urban areas. Both components of pollutant loadings affect the level of nonpoint source pollution, but the problem may be best addressed by considering the hydrology of the system; that is, by disconnecting impervious areas from the drainage system. Reducing the degree of connected impervious area would also be most beneficial in developing areas.

Connected imperviousness and loading

The percentage of impervious area connected to the drainage system is a useful factor in analyzing the differences in unit area water and pollutant loadings arising from various subwatersheds. Tables II-4 and II-5 present average seasonal and annual event unit area loadings for stations ranked by the percentage of connected impervious area in the watershed. Figures II-1 and II-2 graphically show the relationship of average seasonal event unit area loading with the stations' percentage connected impervious area. Table II-6 shows correlation coefficients and regression equations for average seasonal loadings and connected imperviousness, with anomalous data points deleted. There was good correlation ($r > 0.7$) between average water loadings and connected imperviousness for spring, summer and fall. Average suspended solids and total-P loadings showed good correlation with connected imperviousness in spring and summer.

Computed loading estimates were classified as anomalous and not used in the regression and correlation analysis of connected imperviousness if the loading estimate was considered inaccurate because of inadequate monitoring, or if the loading estimate was considered nonrepresentative because of unusual land use or stream conditions. Stations with anomalies are described as follows:

413010 - Water loading values are low because the rating curves were not developed for peak event flows. The peak event flows were estimated by extrapolation of measurements made during lower event flows.

683089 - The pollutant loading values are lower than expected because the flat commercial roof acts as a detention basin. The loadings are more representative of an area with approximately 30% connected imperviousness. The flat roof could effectively reduce the amount of connectedness by detaining the particulate pollutants. The water loadings would not be affected substantially, which is consistent with the relatively high water loadings observed. Also, the parking lot area has few channels and water movement is primarily through sheet flow, which is less effective in transporting particulates.

Table II-4. Average seasonal and annual event unit area loadings of water and suspended solids for 1976 to 1979 ranked by each station's percent connected imperviousness

STORET Number	% Connected Imperviousness	Spring	Summer	Fall	Annual
		Water (m^3/ha)			
683089	45	853+	954+	168	1,778+
413615	43	1,347	977	140	2,216
413010	33	346+	490+	47	953+
413006	28	822	590	150	1,729
413011	28	718	929	132	2,383
413005	9	271	282	64	879
413007	7	350	202	60	742
463001	1	488	143	35	818
413625	0.3	471+	103	16	450+
		Suspended Solids (Kg/ha)			
683089	45	285+	169+	21	410+
413615	43	541	293+	23	778
413010	33	263	156	6	374
413006	28	265	206	83	698
413011	28	205	255+	15	816
413005	9	79	101	43	262
413007	7	109	83	15	231
463001	1	79	75	5	197
413625	0.3	433+	40	2	352+

* Weighted average for 1977, 1978 and 1979.
+ Anomalous data deleted or modified during determination of correleation coefficients for average unit area event loads and percent connected imperviousness.

Table II-5. Average seasonal and annual event unit area loadings of total P- and soluble-P for 1976 to 1979 ranked by each station's percent connected imperviousness

STORET Number	% Connected Imperviousness	Spring*	Summer	Fall	Annual
		Total P (Kg/ha)			
683089	45	.280+	190+	.030	.500
413615	43	.520	.350	.030	.840
413010	33	.400	.250	.020	.610
413006	28	.360	.270	.130	.850
413011	28	.200	.260+	.030	.800
413005	9	.100	.130	.030	.350
413007	7	.150	.090	.020	.320
463001	1	.240	.140	.010	.470
413625	0.3	.270+	.080	.004	.280+
		Soluble P (Kg/ha)			
683089	45	.040	.020	.010	.060
413615	43	.050	.030	id	.080
413010	33	.080	.030	id	.110
413006	28	.070	.030	.020	.110
413011	28	.020	.040	id	.110
413005	9	.020	.020	.01	.060
413007	7	.030	.010	.004	.040
463001	1	.100	.040	.000	.150
413625	0.3	.030	.040	.001	.060

* Weighted average for 1977, 1978 and 1979.

\+ Anomalous data deleted or modified during determination of correlation coefficients for average unit area event loads and percent connected imperviousness.

id Insufficient data.

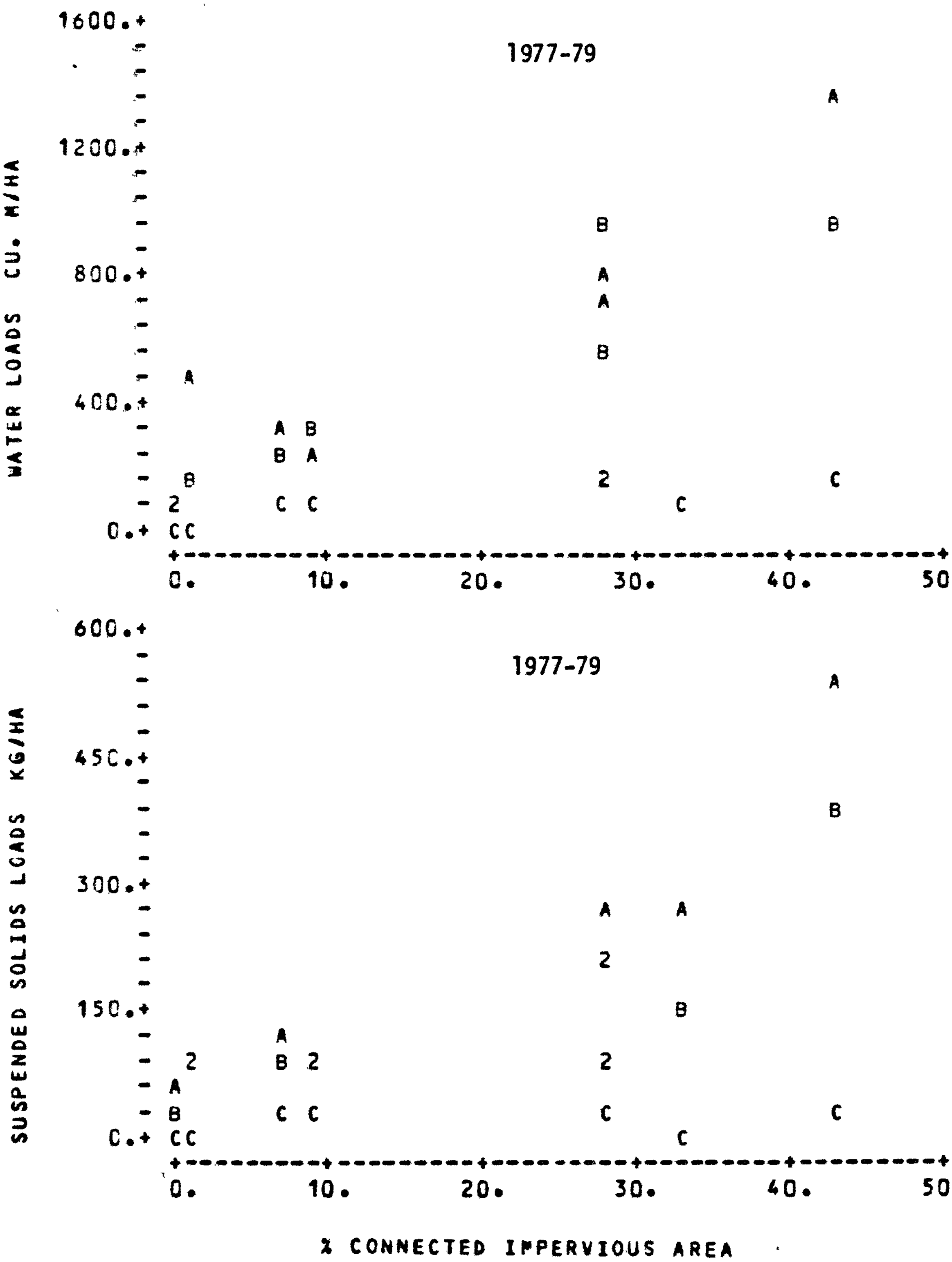

Fig. II-1 Relationship of average seasonal event unit area loadings with degree of connected imperviousness for years 1977 to 1979.

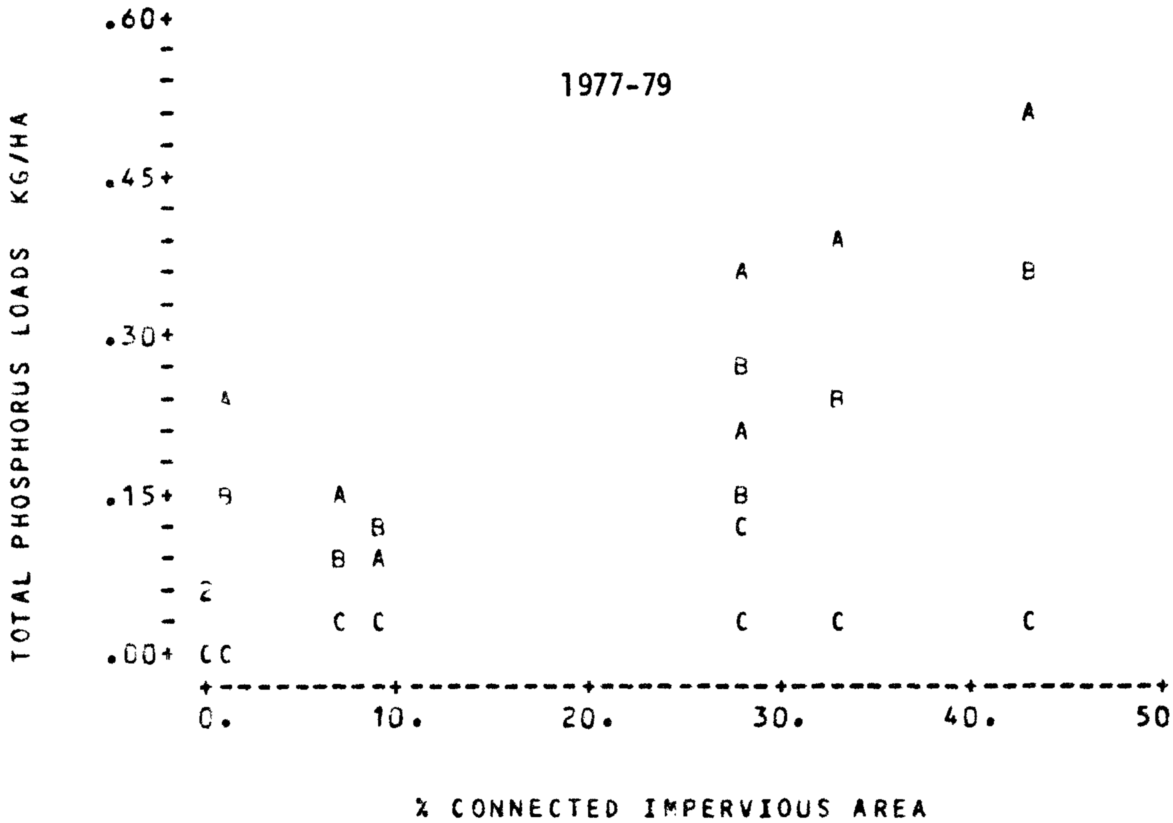

Fig. II-2 Relationship of average seasonal event unit area loadings with degree of connected imperviousness for years 1977 to 1979.

(A = Spring, B = Summer, C = Fall)

Table II-6. Correlation coefficients (r) and regression equations for average seasonal event unit area loadings for 1976 to 1979 and percent connected imperviousness with anomalous data points deleted

	Spring	Summer	Fall
Water			
r - Value	0.931	0.957	0.755
Regression eq.	Y=191+23.7X	Y=100+21.7X	Y=35.3+2.42X
Suspended Solids			
r - Value	0.918	0.808	.273
Regression eq.	Y=28.3+9.15X	Y=36.9+5.58X	Y=15.5+.457X
Total Phosphorus			
r - Value	0.856	0.881	0.383
Regression eq.	Y=.0965+.0084X	Y=.0727+.0056X	Y=.0167+.0009
X			

* Spring is weighted average for 1977, 1978 and 1979.

413011 - The particulate pollutant loadings are considered excessively high in 1977 because 1.2 km of road was constructed during the summer of 1977.

413625 - High water and pollutant loadings in spring of 1979 are difficult to explain, and are considered questionable. There is evidence that sedimentation at the control structure may have affected the flow record. Dumping of fertilizer from an adjacent golf course might have contributed to high total-P values and observed bank erosion upstream might have elevated suspended solids loadings.

The relationships of selected seasonal event unit area water and pollutant loadings with percent connected impervious area, with the anomalous data deleted are presented in Figs. II-A-1 through II-A-8. Correlation coefficients and regression equations for the selected seasonal loadings and connected imperviousness are presented in Table II-A-9. Examination of the table reveals good correlation of unit water loads and connected imperviousness in three of four springs and two of four falls and in all summers. Good correlations of event unit area loadings of suspended solids and total P with connected imperviousness were found in three of four years for spring and summer. Correlation coefficients were generally low for pollutant unit load and connected imperviousness in fall. Poor correlations of event unit area loadings of water and pollutants with connected imperviousness were observed in the spring of 1976. This is probably due to the prolonged frozen ground condition during this year. The impermeable frozen ground would alter the hydrology of the Watershed by temporarily increasing the impervious area.

Rainfall and loading

Pollutant loadings are best estimated and compared on a seasonal basis in the Menomonee River Watershed because of seasonal variations in weather, land cover and land use activities. For example, in the Menomonee River Watershed, spring is characterized by thawing of frozen ground, snowmelt, the emergence of vegetative cover and stable frontal weather systems. Summer is characterized by established vegetative cover and scattered intense rainstorms.

Figures II-A-9 through II-A-28 show seasonal event unit area loadings of water, suspended solids, total-P and soluble-P at stations 413005, 413006, 413011, 413615, and 683089. In general, average seasonal event unit area loadings of water and pollutants were highest in spring followed by summer and fall in decreasing order. This corresponds with the seasonal variation and number of runoff event days shown in Table II-A-1. Seasons in certain years stand out with especially high or low water and pollutant loads. Loadings were highest in spring 1976, fall 1978 and summer 1975 and 1977; lowest in spring 1977 and summer and fall 1976. Seasons in these years also show correspondingly high and low percentages of runoff event days.

The spring of 1976, in addition to high rainfall as shown in Table II-7, also exhibited deep frost and more rain and snow on frozen ground, as indicated in Tables II-A-10 and 11. The frozen ground reduced soil permeability and increased the magnitude and duration of runoff events.

The rainfall data presented in Table II-7 was obtained from rainfall gauging stations located within the subwatersheds and from the National Weather Service at Mitchell Field. For those subwatersheds without a rain gauging station, rain data from the nearest gauging station was used.

Figures II-A-29 through II-A-48 show relationships between seasonal event unit area water, suspended solids, total-P and soluble-P loadings and rainfall. For many stations, good linear relationships exist, especially in spring and summer. Regression equations and correlation coefficients for seasonal loading and rainfall are presented in Tables II-8 through II-11. The correlation coefficients are at low significance levels because they were obtained from only 4 or 5 data points in each season at a given station. However, 80% of the correlation coefficients obtained with at least 4 data points in the spring and summer were good ($r > 0.7$). All stations except 413625 showed good correlations between event unit area water loading and rainfall during spring and summer. The scarcity of good correlations of loading with rainfall in fall is due in part to insufficient data and the generally small range in rainfall and loadings.

Comparison with agricultural watersheds

Management of nonpoint source pollution should not focus too narrowly on agricultural contributions to the exclusion of urban areas within any watershed. Comparison of the average seasonal total and event water and pollutant loadings shows that station 463001, with a predominantly agricultural subwatershed with gently rolling topography similar to that found throughout the Menomonee River Watershed, generally had lower loadings than other stations representing more urbanized subwatersheds (Tables II-3 through II-5).

Table II-12 presents unit area suspended solids and total-P loadings from other Wisconsin agricultural watersheds. Watersheds in Southwest Wisconsin generally have greater relief and steeper slopes than those in the southeastern part of the state. The suspended solids loadings from Southwest Wisconsin are more variable from year to year, but the urban area loadings lie well within the range of the agricultural area loadings. Total-P unit area loadings for the urban and agricultural areas were roughly similar. Considered on a unit area basis, nonpoint source contributions from urban areas may be equal or greater than those from agricultural areas.

Table II-7. Seasonal and annual precipitation (cm) for 1975 to 1979*

STORET** Number	Spring	Summer	Fall	Annual
		1975		
463001	12.3	42.8	9.6	73.7
413011	15.3	39.2	12.6	78.5
413007	18.3	36.9	11.7	80.8
413006	18.3	33.4	10.5	74.6
413005	16.1	36.9	11.3	75.9
Mitchell	20.1	25.4	20.1	74.0
		1976		
463001	30.7	16.5	5.5	56.1
413011	38.6	16.4	6.9	64.4
413007	42.3	13.7	6.6	65.1
413006	37.2	18.3	7.5	66.0
413005	36.6	16.2	6.7	62.5
Mitchell	46.5	20.7	7.3	79.8
		1977		
463001	17.2	46.4	10.3	75.7
413011	14.9	46.2	9.9	73.9
413007	14.7	46.3	9.7	75.5
413006	17.7	45.6	8.4	76.2
413005	15.8	44.5	10.2	75.1
Mitchell	17.0	45.0	8.6	76.9
		1978		
463001	20.0	41.9	9.3	71.2
413011	20.1	49.7	7.6	77.4
413007	17.9	44.5	9.6	72.0
413006	17.9	46.0	9.5	73.4
413005	21.0	55.3	11.1	73.4
Mitchell	22.4	52.7	8.9	103.5
		1979		
463001	18.3	21.7	17.0	57.0
413011	19.3	26.8	17.0	63.1
413007	20.1	22.4	17.0	59.5
413006	19.0	23.9	17.0	59.9
413005	23.4	26.2	17.0	66.6
Mitchell	28.9	22.3	8.9	78.4

* Historical average precipitation values summarized from long term rain gauging stations near the watershed were 5.8, 19.7, 33.6, 14.7 and 73.8 cm for winter, spring, summer, fall and annual respectively.
** 413010 and 413615 use rainfall records from 413005; 413625 and 413089 use rainfall records from 413007.

Table II-8. Correlation coefficients (r) and regression equations for event unit area water loadings and rainfall by seasons for 1975 to 1979

STORET Number	Spring r-value (Regression equation)	Summer r-value (Regression equation)	Fall r-value (Regression equation)
463001	0.998 (Y=-1201+63.6X)	0.838 (Y=-199+11.8X)	id
413011	0.986 (Y=-1510+99.8X)	0.985 (Y=-470+41.8X)	id
413007	0.961 (Y=245+25.1X)	0.821 (Y=-339+7.67X)	0.829 (Y=-48.9+12.1X)
413006	0.953 (Y=-183+40.3X)	0.894 (Y=-339+26.0X)	0.641 (Y=88.4+28.0X)
413005	0.718 (Y=-208+30.8X)	0.916 (Y=-150+12.7X)	0.858 (Y=-57.6+13.4X)
413010	0.564 (Y=172+8.93X)	0.935 (Y=19+13.2X)	id
413615	id	0.889 (Y=-305+35.2X)	0.693 (Y=-38.4+21.5X)
413625	id	0.546 (Y=-45.6+4.70X)	0.651 (Y=-34.4+5.78X)
413089	id	0.968 (Y=-7.32+30.3X)	0.433 (Y=-56.6+25.9X)

id Insufficient data.

Table II-9. Correlation coefficients (r) and regression equations for event unit area suspended solids loadings and rainfall by seasons for 1975 to 1979

STORET Number	Spring r-value (Regression equation)	Summer r-value (Regression equation)	Fall r-value (Regression equation)
463001	Id	0.968 (Y=-113+6.75X)	Id
413011	0.971 (Y=-825+46.7X)	0.372 (Y=-7.53+3.34X)	Id (Y=10.4+.209X)
413006	0.967 (Y=-205+21.9X)	0.834 (Y-037.9+4.13X)	0.392 (Y=-96.3+13.9X)
413010	Id	0.578 (Y=--69.5+2.50X)	Id
413615	Id	0.678 (Y=-109+11.3X)	Id
413625	Id	0.552 (Y=-23.1+1.99X)	Id
413089	Id	0.820 (Y=-65.4+3.29X)	0.403 (Y=-45+7.57X)

Id Insufficient data

Table II-10. Correlation coefficients (r) and regression equations for event unit area total-P loadings and rainfall by seasons for 1975 to 1979

STORET Number	Spring r-value (Regression equation)	Summer r-value (Regression equation)	Fall r-value (Regression equation)
463001	id	0.921 (Y=-194+.0114X)	id
413011	0.959 (Y=-.703+.0411X)	0.578 (Y=-.053+.0093X)	id
413007	0.905 (Y=1.0392+.008X)	0.910 (Y=-.0313+.0037X)	id
413006	0.845 (Y=-.137+.0105X)	0.931 (Y=-.109+.0133X)	0.811 (Y-0.742+.102X)
413005	0.956 (Y=-.200+.0136X)	0.908 (Y=-.0327+.0046X)	0.881 (Y=-.0305+.0065X)
413010	id	0.961 (Y=-.0138+.0066X)	id
413615	id	0.914 (Y=-.159+.144X)	id
413625	id	0.017 (Y=-.0752+.0001X)	id
413089	id	0.890 (Y=-.0665+.0039X)	-.051 (Y=-.0303-.0005X)

id Insufficient data

Table II-11. Correlation coefficients (r) and regression equations for event unit area soluble-P loadings and rainfall by seasons for 1976 to 1979

STORET Number	Spring r-value (Regression equation)	Summer r-value (Regression equation)	Fall r-value (Regression equation)
463001	id	0.768 (Y=-.0670+.0037X)	id
413011	0.941 (Y=-118+.0062X)	0.979 (Y=-.237+.0019X)	id
413007	0.129 (Y=-0179+.0002X)	0.657 (Y=.0001+.0003X)	id
413006	-.391 (Y=-0988-.0014X)	0.991 (Y=-.0005+.0007X)	0.675 (Y=-.177+.0235X)
413005	0.885 (Y=-.0497+.0031X)	0.864 (Y=-.0106+.0007X)	0.878 (Y=-.0138+.0023X)
413010	id	0.983 (Y=.0027+.0008X)	id
413615	id	0.906 (Y=-.0079+.0009X)	id
413625	id	-0.283 (Y=.0605-.0009X)	id
413089	id	0.623 (Y=-.0014+.0008X)	0.706 (Y=-.0136+.0025X)

id Insufficient data.

Table II-12. Annual unit area loadings* of suspended solids and total-P in urban and agricultural watersheds

Watershed	Area (mi^2)	Urban Area(%)	Suspended Solids ($Tons/mi^2$)		Total Phosphorus ($Tons/mi^2$)	
			1978	1979	1978	1979
			Agricultural areas**			
Yellowstone River	28.5	0	220	54		
Steiner Branch	5.9	0	369	85	0.4	0.1
Onion River	100	2		90		0.2
Grant River	26.9	5	970	310		
Little Menomonee	8.0	12	96	275	0.2	0.1
			Urban areas***			
Menomonee River	123	44	128	179	0.1	0.05
Underwood Creek	18.2	65	122	115	0.1	0.1
Honey Creek	10.3	79	179	237	0.3	0.2
Noyes Creek	2.2	90	150	160	0.2	0.1

* Suspended solids values included event and nonevent loadings and total phosphorus values are only event loadings.

** The Yellowstone, Steiner Branch and Grant Watersheds are in southwest Wisconsin, and the Onion and Little Menomonee watersheds are in southeast Wisconsin.

*** The urban watersheds are in southeast Wisconsin.

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Appendix A

Monitoring Data from 1975 to 1979

Appendix II-A contain tabular and fictural material which are grouped in the following manner to correspond to the order shown in the main text.

Table or Figure Nos.	Description
Tables II-A-1 and II-A-2	Individual event flow and concentrations at 413005
Table II-A-3	Number of seasonal event days for 1975 to 1979
Tables II-A-4 to II-A-8	Seasonal event unit area loadings of pollutants ranked by the amount of connected imperviousness
Figure II-A-1 to II-A-8	Relationship of selected seasonal event unit area water and pollutant loadings with degree connected imperviousness for all years
Figures II-A-9 to II-A-28	Seasonal event unit area loadings of water and pollutants for selected stations
Tables II-A-9	Correlation coefficients and regression equations for selected event unit area water and pollutant loadings and percent connected imperviousness by season for 1975 to 1979
Figures II-A-29 to II-A-48	Relationship of seasonal event unit area water and pollutant loadings and rainfall
Tables II-A-10 to II-A-11	Snow and frost depth, and snowfall and rainfall on frozen ground for 1975 to 1979

Table II-A-1. Flow (cms) and pollutant concentrations (mg/l) at 413005 (70th Street) for selected events and baseflow in 1976

Non-Event Sampling Dates	Event Times: Start and Stop	Event Times: Samples Date	Event Times: Samples Time	Flows	Suspended Solids	Total P	Soluble P	Chloride
760429				4.8	32	0.24	0.110	85
	7605051700	760505	1755	4.4	120	0.35	0.080	90
			1855	26.9	540	0.67	0.038	38
			1955	47.9	594	0.62	0.039	26
			2050	47.3	432	0.58	0.060	30
			2340	19.4	226	0.42	0.093	36
	7605082000	760506	1020	8.9	72	0.29	0.120	78
760511				3.2	21	0.26	0.120	115
760721				.4	21	0.27	0.090	180
	7607280700	760728	0728	.5	98	0.54	0.076	145
			0808	1.2	150	0.62	0.110	140
			0810	1.2	180	0.63	0.007	140
			0833	2.2	294	0.81	0.062	115
			0903	5.0	544	2.10	0.510	70
			0932	6.9	876	1.60	0.003	95
			0935	7.1	708	1.30	0.003	110
			1000	6.7	477	0.97	0.003	130
			1003	6.6	508	1.00	0.003	110
			1701	1.6	55	0.38	0.085	90
	7607300800		1704	1.6	62	0.34	0.087	85
760804				.4	82	0.27	0.060	170

Table II-A-2. Flows (cms) and pollutant concentrations (mg/l) at 413005 for selected events in 1977

Start and Stop Times	Sampling Date	Sampling Time	Flows	Suspended Solids	Total P	Soluble P	Chloride	Total* Lead
7706300700								
	770630	0720	0.5	88	0.32	0.101	105	91
		0825	id	455	0.64	0.074	69	id
		0900	17.7	652	1.06	0.074	88	349
		0925	15.9	608	0.76	0.058	65	247
		1025	24.6	509	0.66	0.057	36	225
		1125	id	276	0.48	0.069	36	id
		1325	5.5	147	0.42	0.068	35	89
		1410	id	171	0.30	0.078	38	id
	770701	1035	1.1	42	0.26	0.133	158	2
7707012200								
7708032100								
	770803	2145	2.1	101	0.29	0.029	130	id
		2240	11.4	196	0.74	0.036	109	id
		2310	14.3	442	1.09	0.017	63	id
	770804	0010	12.1	1034	0.52	0.048	50	id
		0110	7.3	520	0.65	0.046	33	id
		0340	3.6	216	0.35	0.055	35	id
		0635	2.1	128	0.30	0.085	86	id
		1035	1.8	46	0.20	0.073	60	id
7708060600								

* ug/l
id Insufficient data.

Table II-A-3. Number of seasonal event days for years 1975 to 1979

Season	413005	413006	413007	463001	413011	413010	683089	413615	413625
					1975				
Spring	50	24	24	19	40	15	na*	na	na
Summer	54	30	20	24	21	7	na	na	na
Fall	16	17	13	7	22	6	na	na	na
					1976				
Spring	74	40	50	61	32	13	na	na	na
Summer	16	16	8	7	14	4	na	na	na
Fall	8	5	3	4	4	1	na	na	na
					1977				
Spring	21	20	17	7	16	4	na	na	na
Summer	47	33	27	19	31	6	na	na	na
Fall	9	8	6	4	9	2	na	na	na
					1978				
Spring	37	26	32	10	17	18	10	9	2
Summer	38	27	26	14	27	14	10	10	10
Fall	22	13	12	15	13	12	4	3	5
					1979				
Spring	29	39	24	23	29	31	20	21	18
Summer	36	32	23	12	31	16	6	7	8
Fall	13	11	9	9	18	4	5	4	2
					Average of Five Years				
Spring	42	30	29	24	27	16	Id	Id	Id
Summer	38	28	21	15	25	9	Id	Id	Id
Fall	14	11	9	8	13	5	Id	Id	Id

* Not available.
Id Insufficient data.

Table II-A-4. Summary of seasonal event unit area water loadings (m^3/ha) ranked by each station's percent connected imperviousness

STORET Number	% Connected Imperviousness	1975	1976	1977	1978	1979
			Spring			
683089	45	id	id	683+	1,113+	829+
413615	43	id	id	443	1,997	1,764
413010	33	id	607+	229+	599+	277+
413006	28	560	1,590	370	780	1,216
413011	28	id	3,253	342	771	1,054
413005	9	980	1,320	140	294	376
413007	7	240	870	80	389	581
463001	1	id	1,745	id	189	687
413625	0.3	id	id	96	100	1,118+
			Summer			
683089	45	id	357	1246	1482	731
413615	43	id	127	1593	1350	837
413010	33	id	145+	647+	696+	471+
413006	28	300	280	810	1033	238
413011	28	id	235	1145	1727	611
413005	9	400	70	280	613	165
413007	7	280	60	210	405	136
463001	1	id	24	132	403	12
413625	0.3	id	1.1	32	308	73
			Fall			
683089	45	id	90	103	214	265
413615	43	id	14	237	153	156
413010	33	id	46	62	id	32
413006	28	210	90	200	134	175
413011	28	id	91	id	135	170
413005	9	100	30	100	70	58
413007	7	80	20	90	60	69
463001	1	id	0	67	10	3
413625	0.3	id	3	9	32	19
			Annual			
683089	45	id	447	2033	2809	1825
413615	43	id	233	2373	3500	2757
413010	33	id	798+	938+	1295+	781+
413006	28	1070	1960	1380	1947	1630
413011	28	id	3579	1487	2633	1836
413005	9	1490	1420	520	978	599
413007	7	600	950	380	854	786
463001	1	id	1769	199	602	702
413625	0.3	id	4	138	450	1210+

id Insufficient data.

+ Anomolous data deleted during determination of correlation coefficients for selected event loads unit area and percent connected imperviousness.

Table II-A-5. Summary of seasonal event unit area loadings* of suspended solids (kg/ha) ranked by each station's percent connected imperviousness

STORET Number	% Connected Imperviousness	1975	1976	1977	1978	1979
			Spring			
683089	45	id	id	350+	379+	151+
413615	43	id	id	230	1128	413
413010	33	id	142	169	392	id
413006	28	288	835	129	344	327
413011	28	id	1423	49	282	303
413005	9	127	230	41	99	101
413007	7	286	133	26	122	179
463001	1	id	275	id	90	74
413625	0.3	id	id	7	97	1112+
			Summer			
683089	45	id	78+	188+	231+	182+
413615	43	id	10+	695	305	162
413010	33	id	83	265	146	140
413006	28	142	77	452	231	65
413011	28	id	51	780+	70	119
413005	9	147	36	168	167	32
413007	7	178	38	84	169	41
463001	1	id	8	115	175	2
413625	0.3	id	0.2	11	127	22
			Fall			
683089	45	id	6	4	60	13
413615	43	id	4	51	14	id
413010	33	id	4	9	id	id
413006	28	46	10	47	201	75
413011	28	id	3	id	id	27
413005	9	14	4	48	114	6
413007	7	3	7	36	id	3
463001	1	id	1	13	id	.1
413625	0.3	id	0.1	1	5	id
			Annual			
683089	45	id	84+	541+	671+	346+
413615	43	id	51	990	1446	625
413010	33	id	230	443	538	285
413006	28	486	922	628	776	467
413011	28	id	1477	829	515	444
413005	9	288	271	257	380	139
413007	7	466	178	146	378	223
463001	1	id	283	128	299	77
413625	0.3	id	0.3	19	229	1161+

* 95% confidence limits presented in tables I-A-48 and II-A-44 of volume 3 and table I-A-31 and I-A-35 of volume 12.

id Insufficient data.

+ Anomalous data deleted during determination of correlation coefficients for unit area event loads and percent connected imperviousness.

Table II-A-6. Summary of seasonal event unit area loadings* of total-P (kg/ha) ranked by each station's percent connected imperviousness

STORET Number	% Connected Imperviousness	1976	1977	1978	1979
		Spring			
683089	45	id	0.263+	0.473+	0.102+
413615	43	id	0.239	1.044	0.422
413010	33	0.276	0.243	0.628	id
413006	28	0.641	0.282	0.479	0.346
413011	28	1.287	0.075	0.292	0.253
413005	9	0.459	0.055	0.134	0.113
413007	7	0.307	0.040	0.177	0.233
463001	1	0.633	id	0.177	0.283
413625	0.3	id	0.039	0.079	0.610+
		Summer			
683089	45	0.095+	0.216+	0.263+	0.186+
413615	43	0.022	0.629	0.523	0.231
413010	33	0.122	0.352	0.349	0.167
413006	28	0.119	0.485	0.340	0.134
413011	28	0.069	0.614+	0.213	0.132
413005	9	0.065	0.211	0.207	0.044
413007	7	0.006	0.110	0.163	0.069
463001	1	0.014	0.174	0.346	0.009
413625	0.3	0.001	0.012	0.122	0.177+
		Fall			
683089	45	0.024	0.007	0.037	0.036
413615	43	0.013	0.060	0.029	id
413010	33	0.017	0.022	id	id
413006	28	0.048	0.095	0.284	0.083
413011	28	0.015	id	id	0.037
413005	9	0.017	0.038	0.044	0.017
413007	7	0.004	0.031	id	0.013
463001	1	0.000	0.025	id	0.001
413625	0.3	0.001	0.002	0.008	id
		Annual			
683089	45	0.419+	0.486+	0.773+	0.324+
413615	43	0.111	0.946	1.596	0.708
413010	33	0.415	0.617	0.978	0.419
413006	28	0.883	0.862	1.102	0.563
413011	28	1.372	0.689	0.713	0.422
413005	9	0.541	0.304	0.385	0.174
413007	7	0.317	0.181	0.447	0.315
463001	1	0.647	0.200	0.746	0.293
413625	0.3	0.001	0.054	0.210	0.855+

* 95% confidence limits presented in tables I-A-49 and II-A-46 of volume 3 and tables I-A-32 and I-A-36 of volume 12.

+ Anomalous data deleted during determination of correlation coefficients for selected unit area event loads and percent connected imperviousness.

Table II-A-7. Summary of seasonal event unit area loadings* of soluble-P (kg/ha) ranked by each station's percent connected imperviousness

STORET Number	% Connected Imperviousness	1976	1977	1978	1979
		Spring			
683089	45	id	0.007	0.085	0.012
413615	43	id	0.010	0.069	0.089
413010	33	0.066	0.010	0.168	id
413006	28	0.009	0.025	0.095	0.101
413001	28	0.188	0.008	0.029	0.020
413005	9	0.106	0.009	0.037	0.010
413007	7	0.016	0.005	0.021	0.054
463001	1	0.178	id	0.041	0.144
413625	0.3	id	0.022	0.006	0.047
		Summer			
683089	45	0.010	0.017	0.056	0.015
413615	43	0.003	0.026	0.048	0.026
413010	33	0.013	0.037	0.046	0.027
413006	28	0.015	0.033	0.036	0.017
413011	28	0.007	0.062	0.065	0.021
413005	9	0.005	0.012	0.037	0.007
413007	7	0.001	0.008	0.020	0.011
463001	1	0.002	0.023	0.131	0.002
413625	0.3	0.000	0.003	0.020	0.107+
		Fall			
683089	45	0.002	id	0.007	0.013
413615	43	0.000	id	0.005	id
413010	33	0.004	id	id	id
413006	28	0.009	0.014	0.067	0.005
413011	28	0.006	id	id	0.009
413005	9	0.003	0.008	0.014	0.004
413007	7	0.001	0.009	id	0.003
463001	1	0.000	0.000	id	0.000
413625	0.3	0.000	id	0.003	0.000
		Annual			
683089	45	0.012	0.023	0.148	0.040
413615	43	0.025	0.036	0.122	0.117
413010	33	0.083	0.047	0.214	0.093
413006	28	0.033	0.070	0.198	0.124
413011	28	0.201	0.070	0.126	0.050
413005	9	0.113	0.030	0.088	0.021
413007	7	0.016	0.022	0.056	0.068
463001	1	0.179	0.023	0.259	0.146
413625	0.3	0.001	0.025	0.029	0.195

* 95% confidence limits presented in tables I-A-50 and II-A-47 of volume 3 and table I-A-33 and I-A-37 of volume 12.

+ Anomalous data deleted during determination of correlative coefficients for selected unit area event loads and percent connected imperviousness.

Table II-A-8. Summary of seasonal event unit area loadings of lead (kg/ha) at 413005 (70th Street)

STORET Number	% Connected Imperviousness	1975	1976	1977	1978	1979*
			Spring			
413005	9	id	0.289	id	id	0.041
			Summer			
413005	9	0.168	0.101	0.063	id	0.022
			Fall			
413005	9	id	id	id	id	0.006

id insufficient data.
* Cadmium loading for spring, summer, and fall was 0.421, 0.114 and 0.025 kg/ha, respectively.

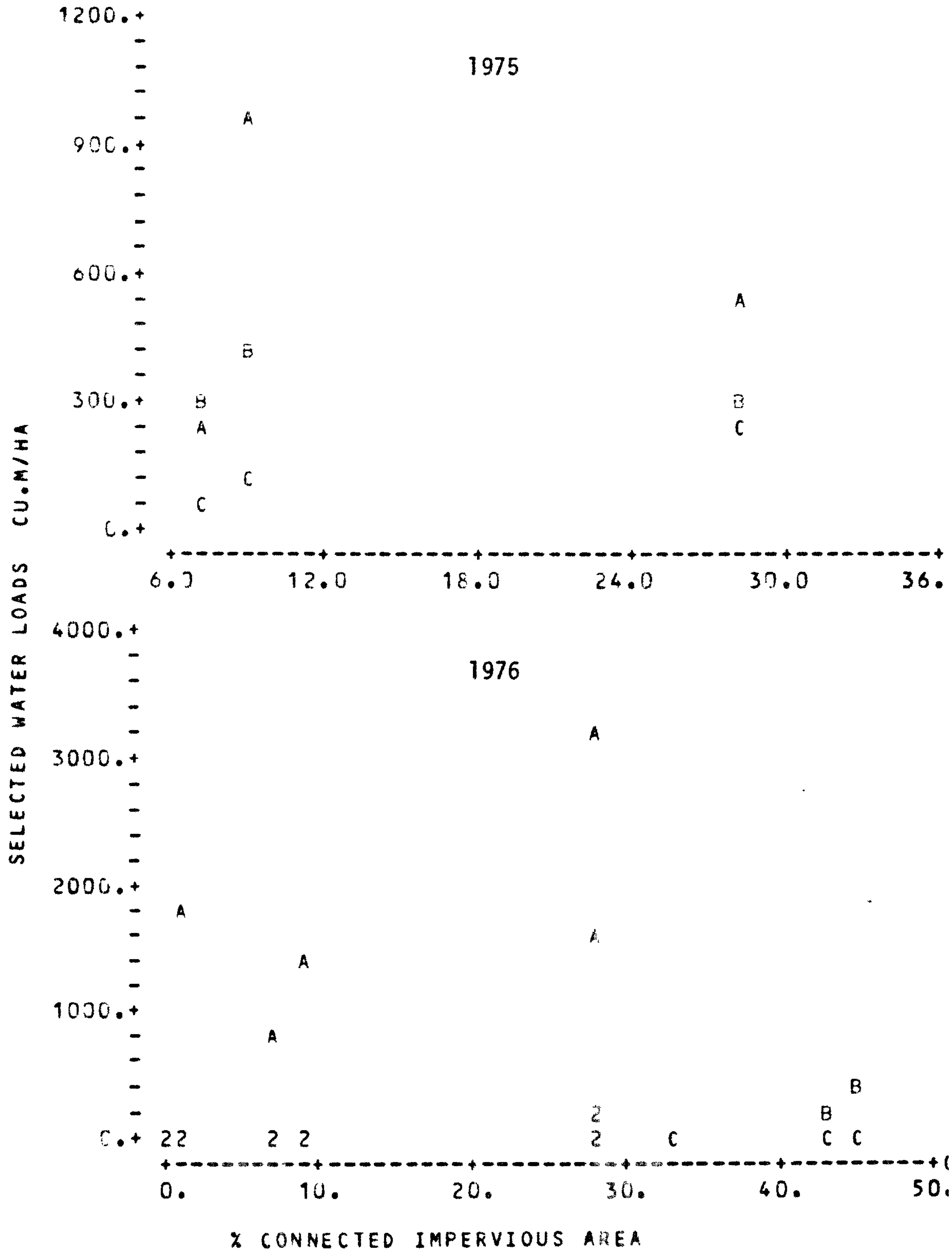

Fig. II-A-1. Relationship of selected seasonal event unit area water loadings with degree of connected imperviousness for 1975 and 1976. (A = Spring, B = Summer, C = Fall)

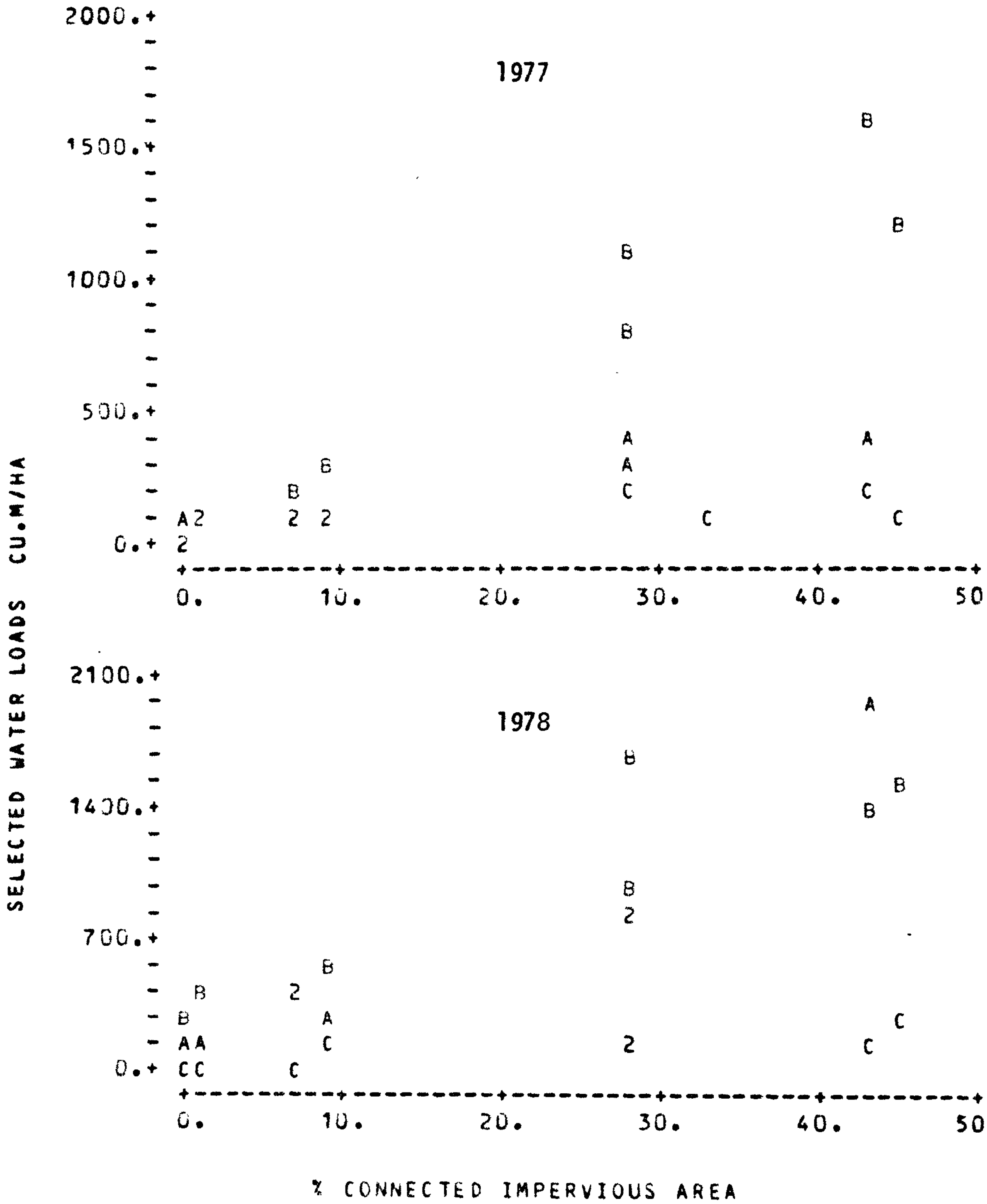

Fig. II-A-2. Relationship of selected seasonal event unit area water loadings with degree of connected imperviousness for 1977 and 1978.
(A = Spring, B = Summer, C = Fall)

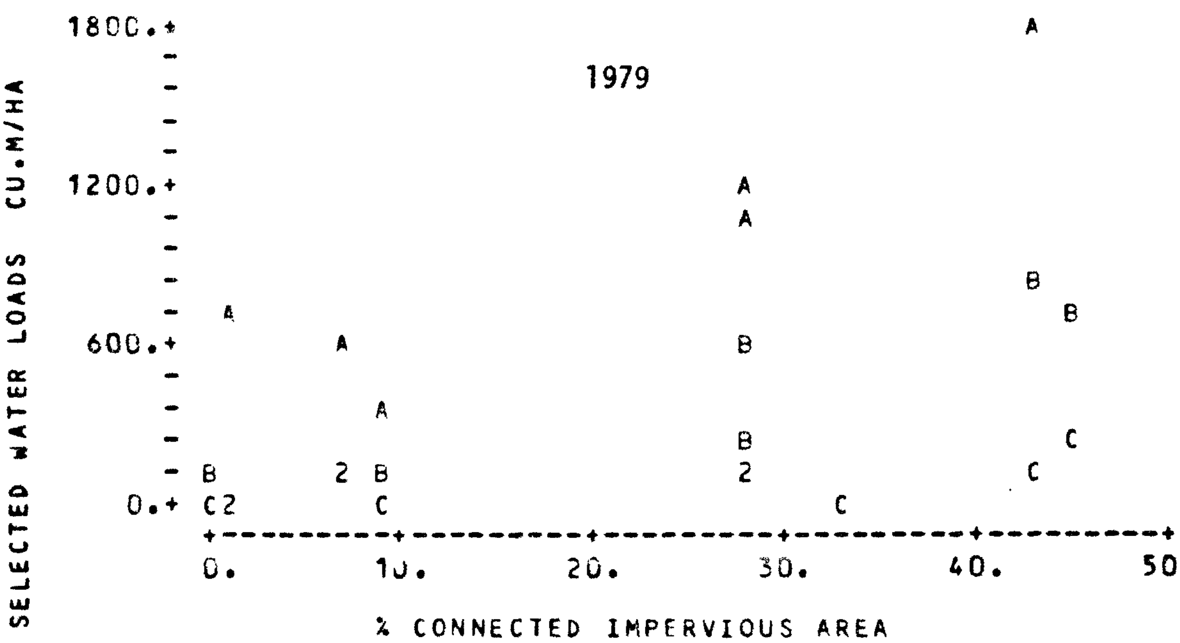

Fig. II-A-3. Relationship of selected seasonal event unit area water loadings with degree of connected imperviousness for 1979.

(A = Spring, B = Summer, C = Fall)

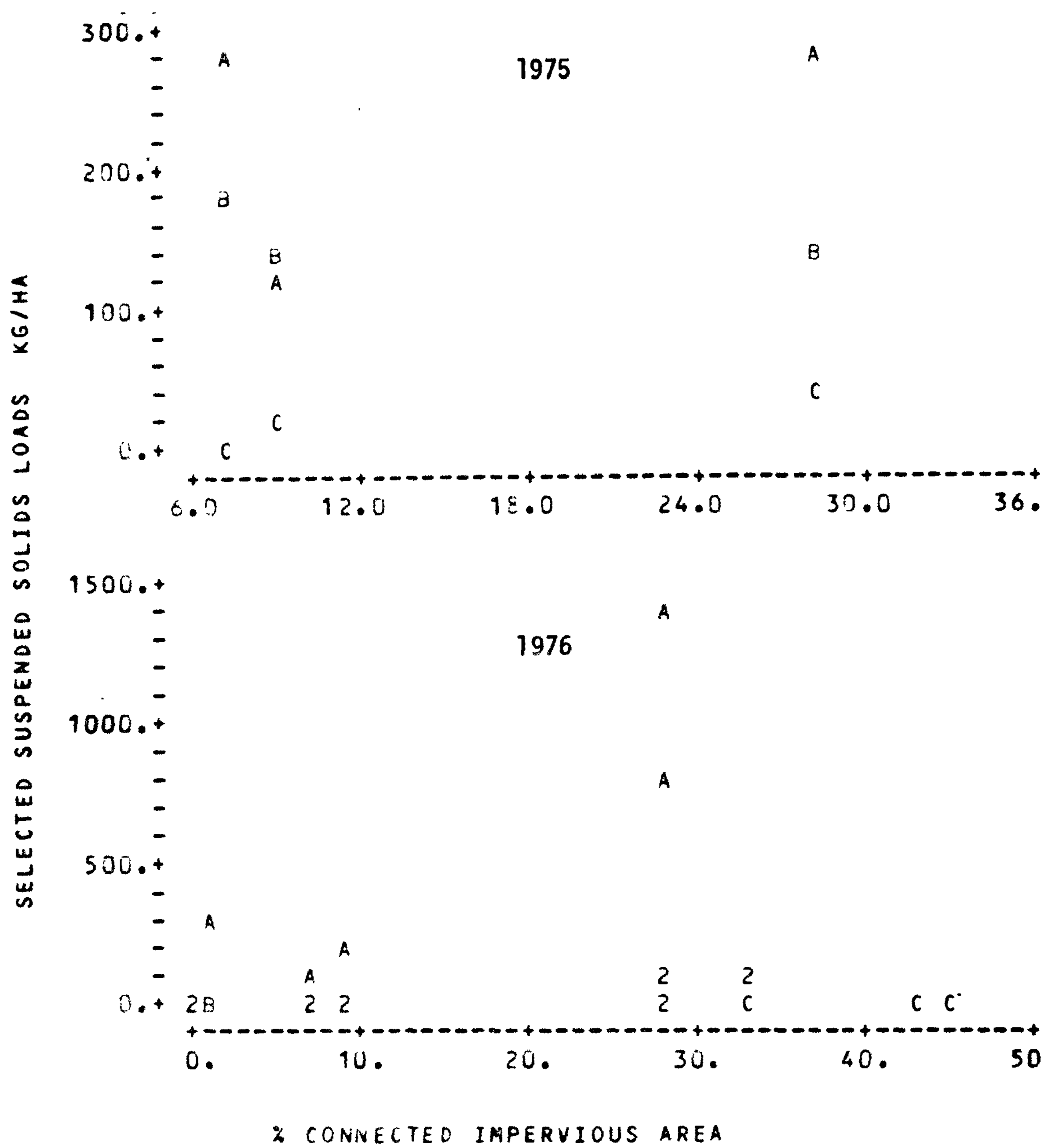

Fig. II-A-4. Relationship of selected seasonal event unit area suspended solids loadings with degree of connected imperviousness for 1975 and 1976.

(A = Spring, B = Summer, C = Fall)

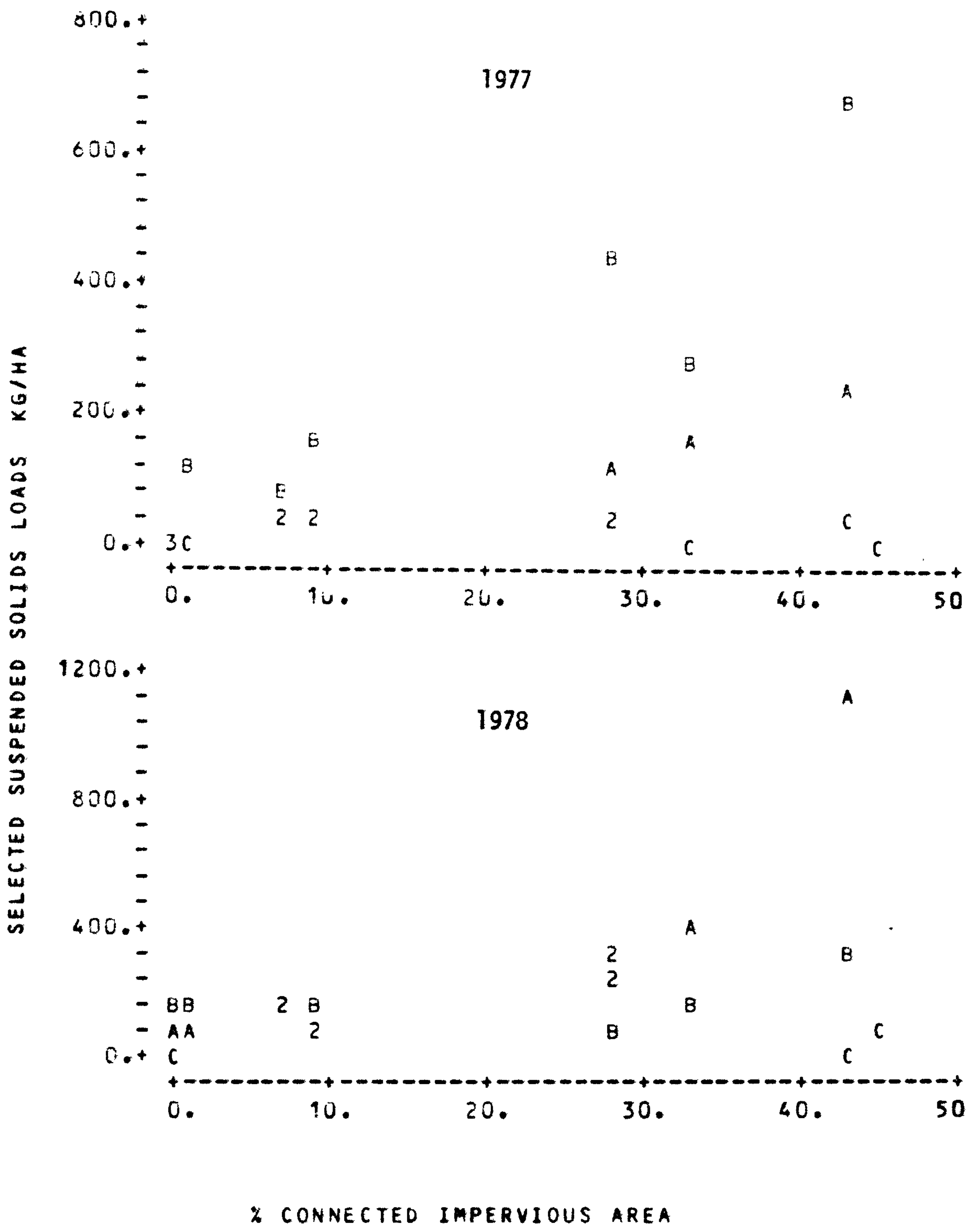

Fig. II-A-5. Relationship of selected seasonal event unit area suspended solids loadings with degree of connected imperviousness for 1977 and 1978. (A = Spring, B = Summer, C = Fall)

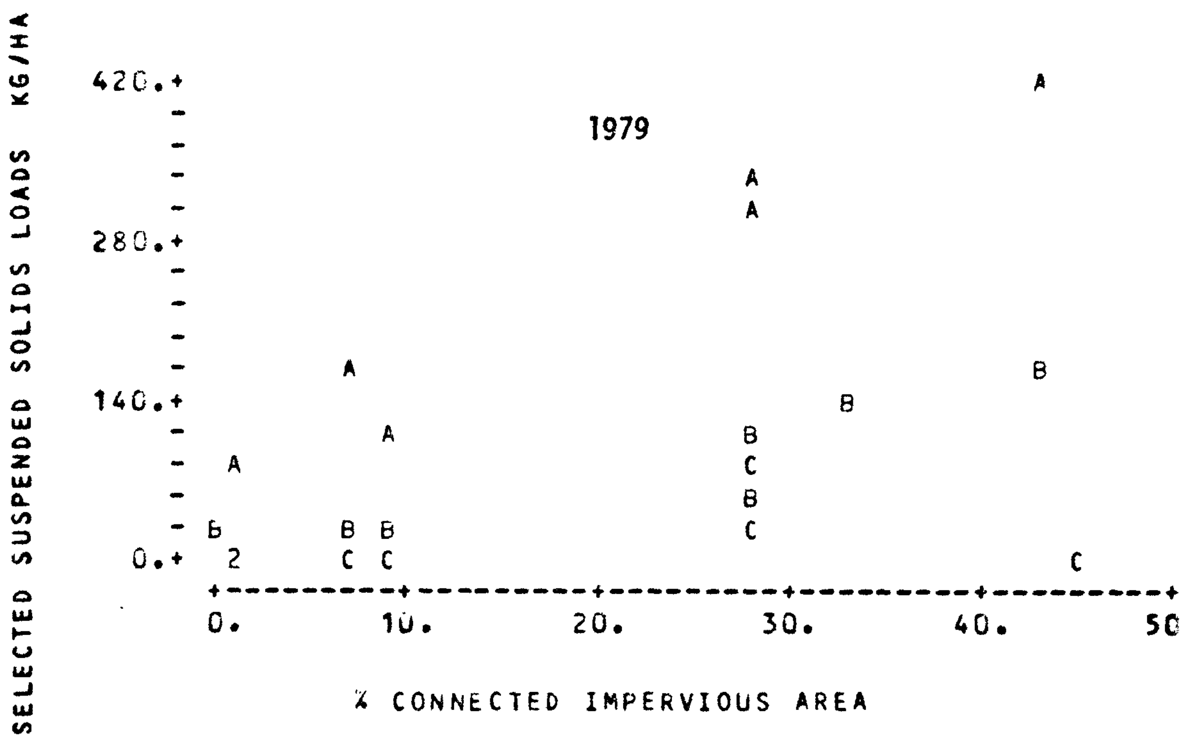

Fig. II-A-6. Relationship of selected seasonal event unit area suspended solids loadings with degree of connected imperviousness for 1979.

(A = Spring, B = Summer, C = Fall)

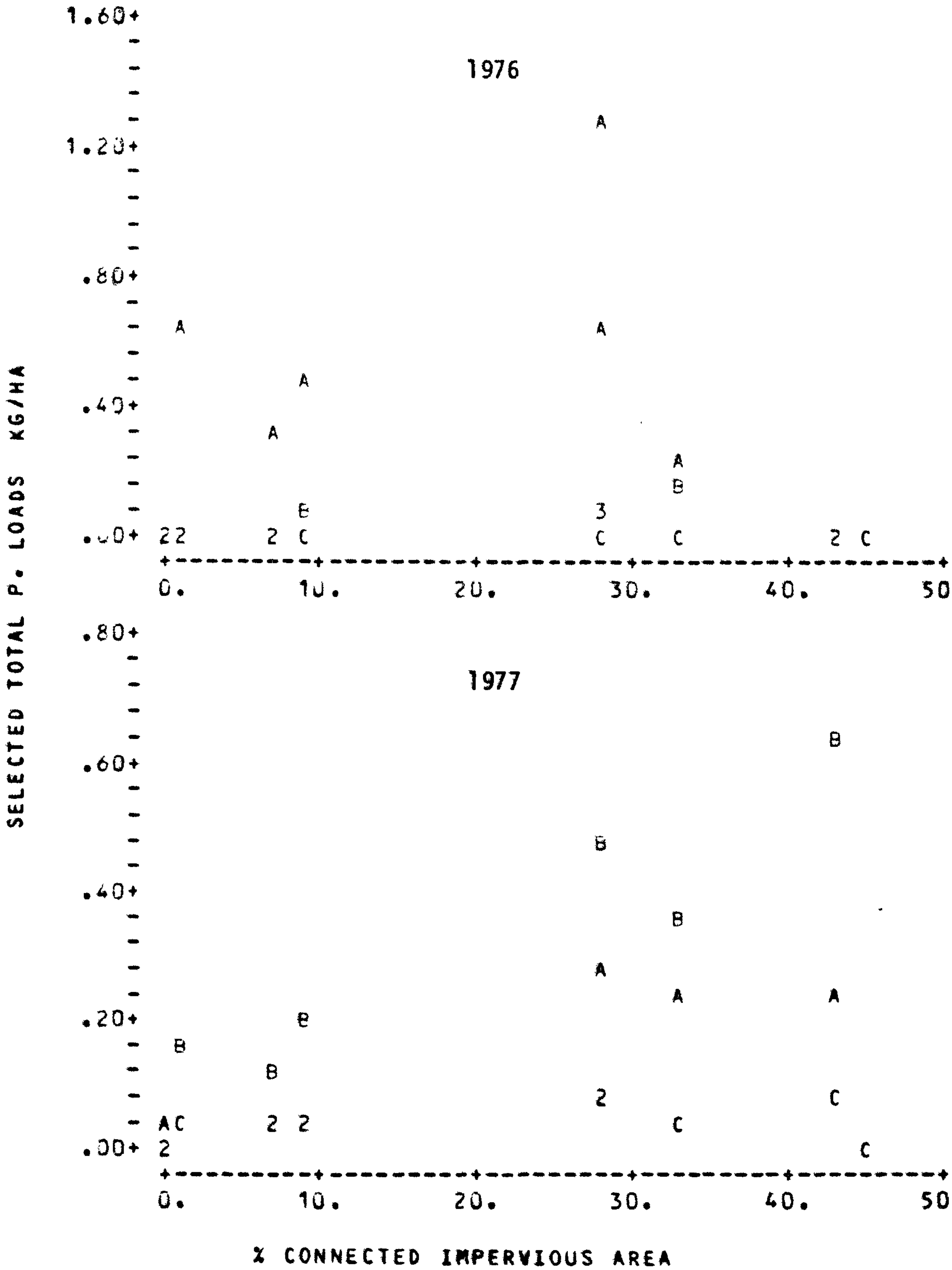

Fig. II-A-7. Relationship of selected seasonal event unit area total-P loadings with degree of connected imperviousness for 1976 and 1977. (A = Spring, B = Summer, C = Fall)

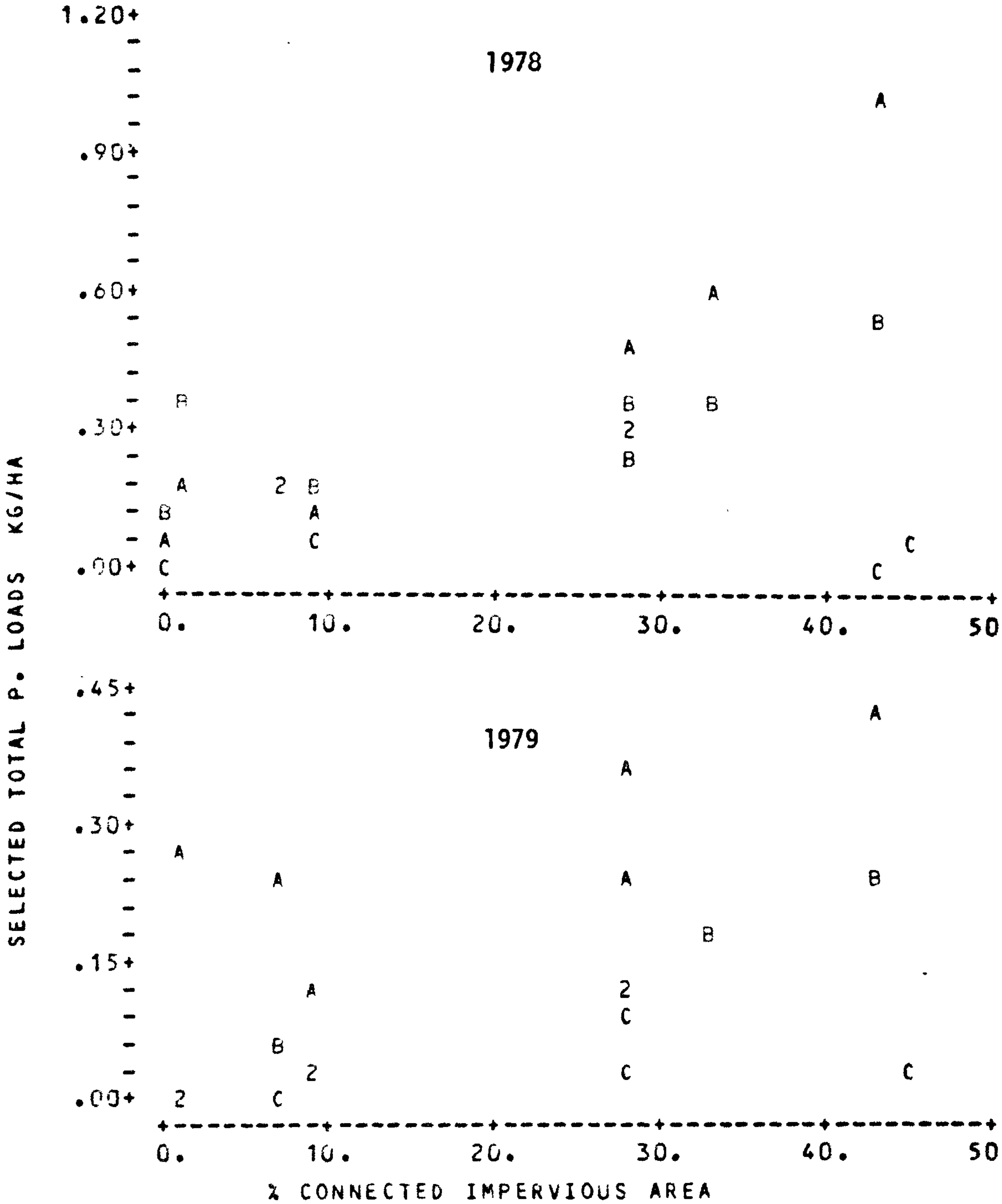

Fig. II-A-8. Relationship of selected seasonal event unit area total P loadings with degree of connected imperviousness for 1978 and 1979.
(A = Spring, B = Summer, C = Fall)

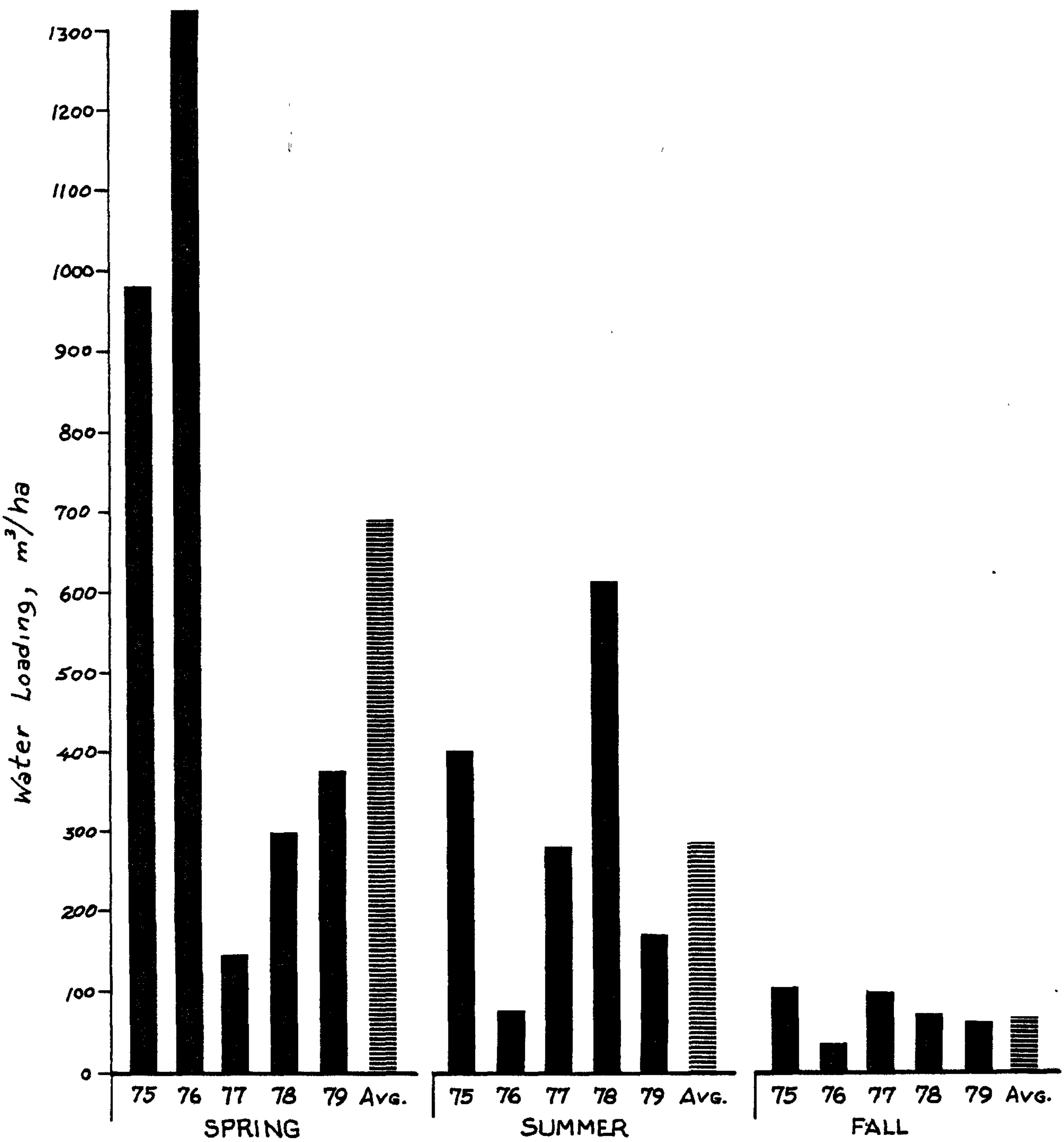

Fig. II-A-9. Seasonal event unit area loadings of water at 413005 (70th Street).

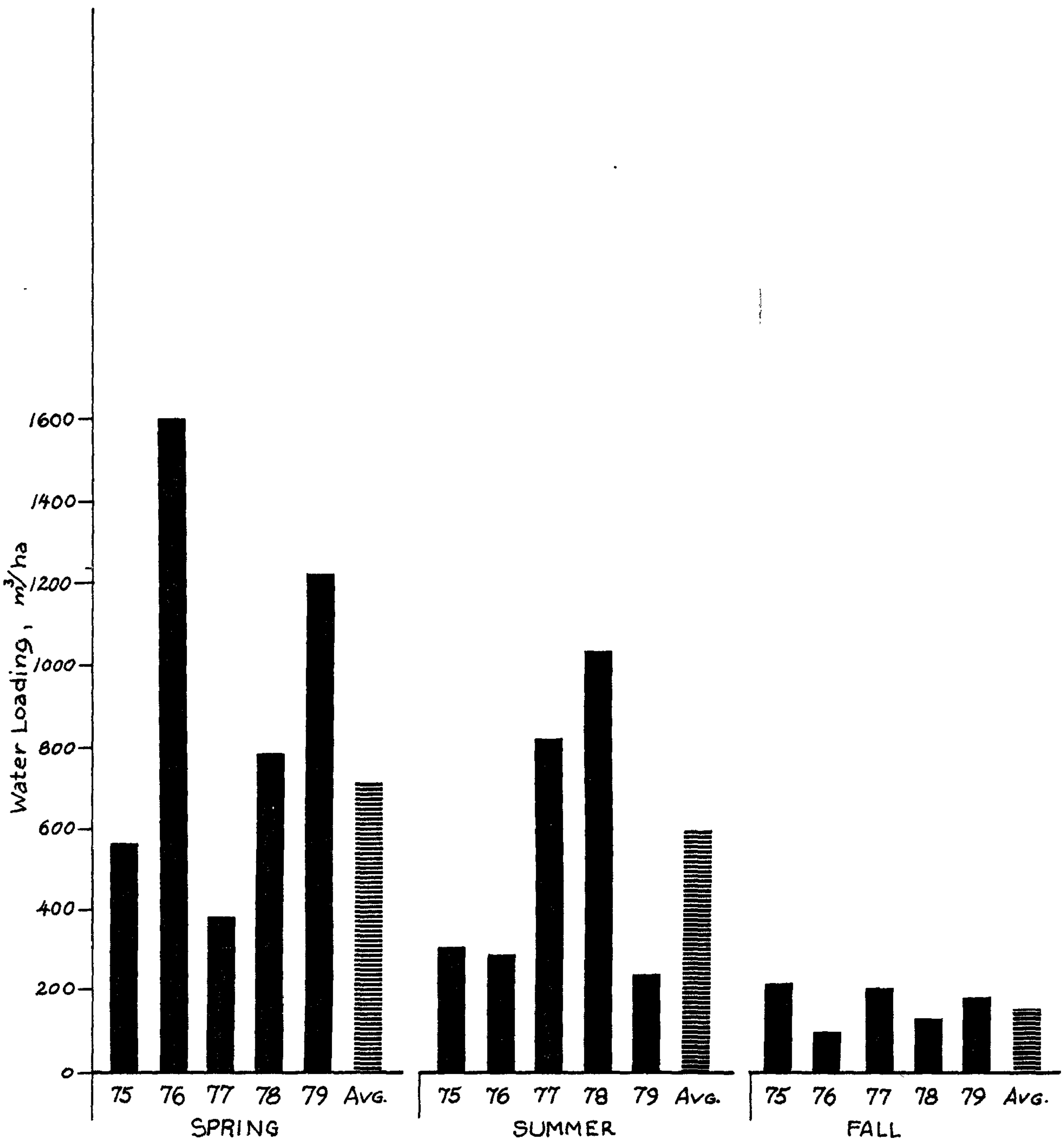

Fig. II-A-10. Seasonal event unit area loadings of water at 413006 (Honey Creek).

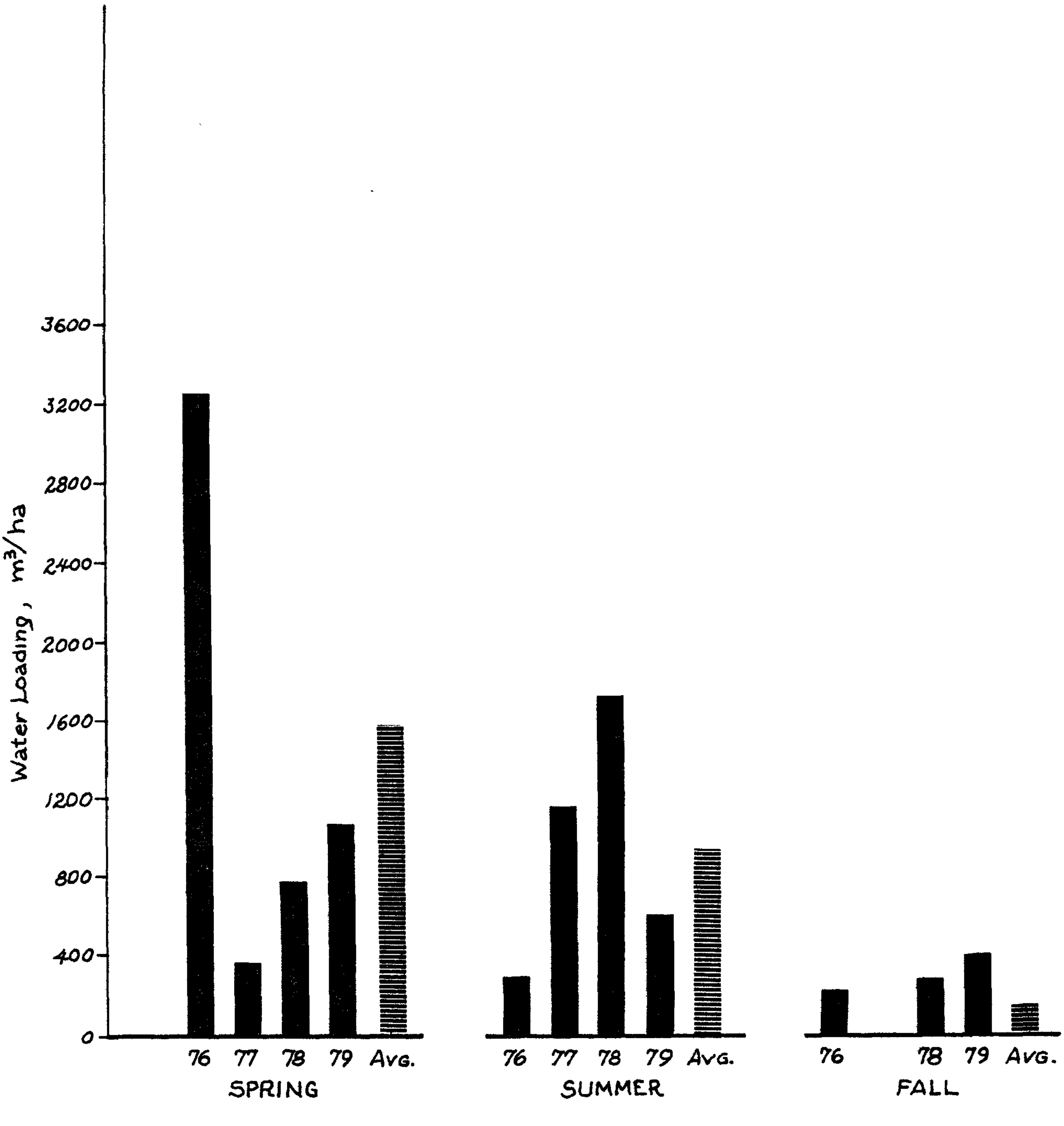

Fig. II-A-11. Seasonal event unit area loadings of water at (Noyes Creek).

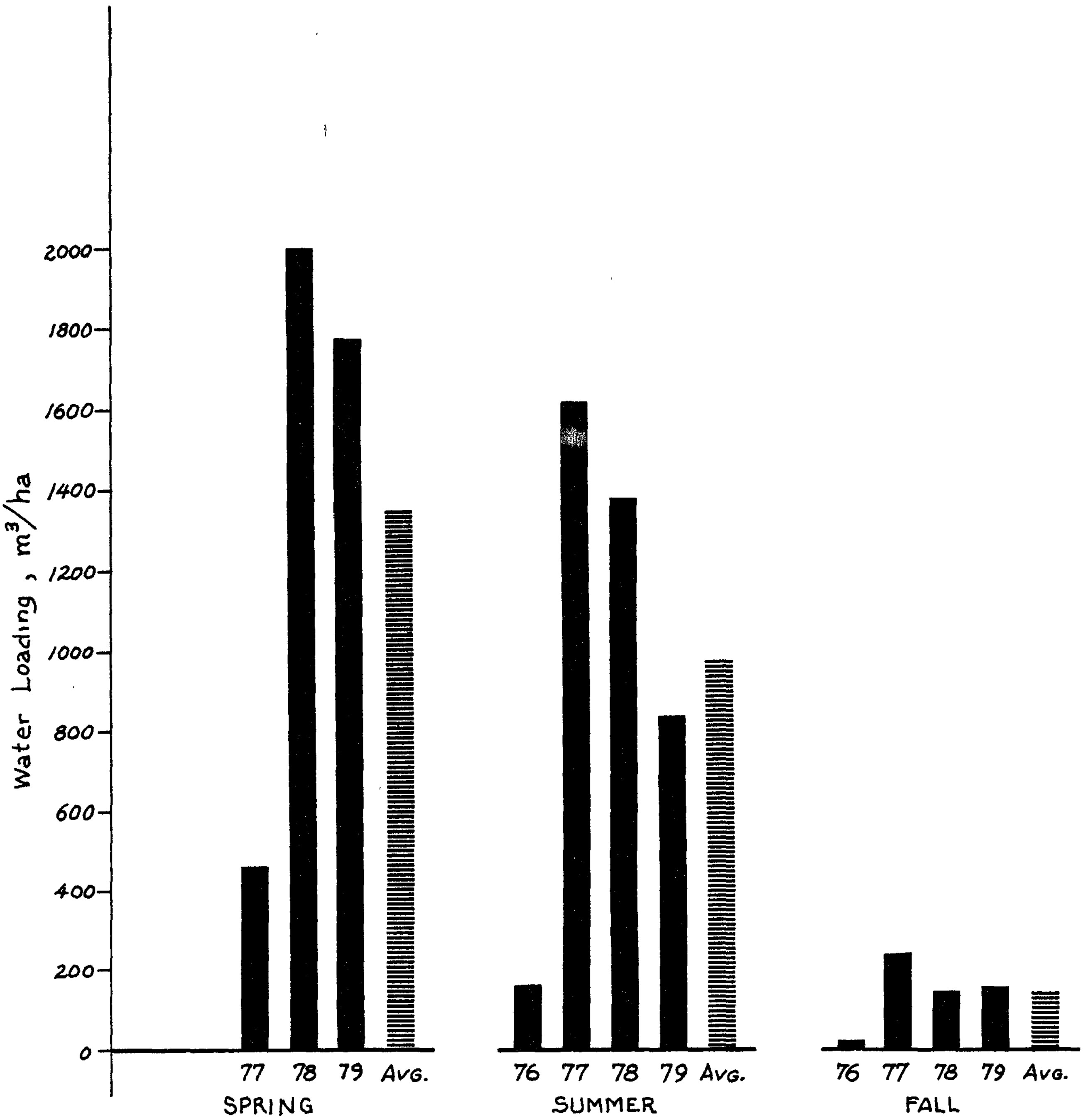

Fig. II-A-12. Seasonal event unit area loadings of water at 413615 (Stadium).

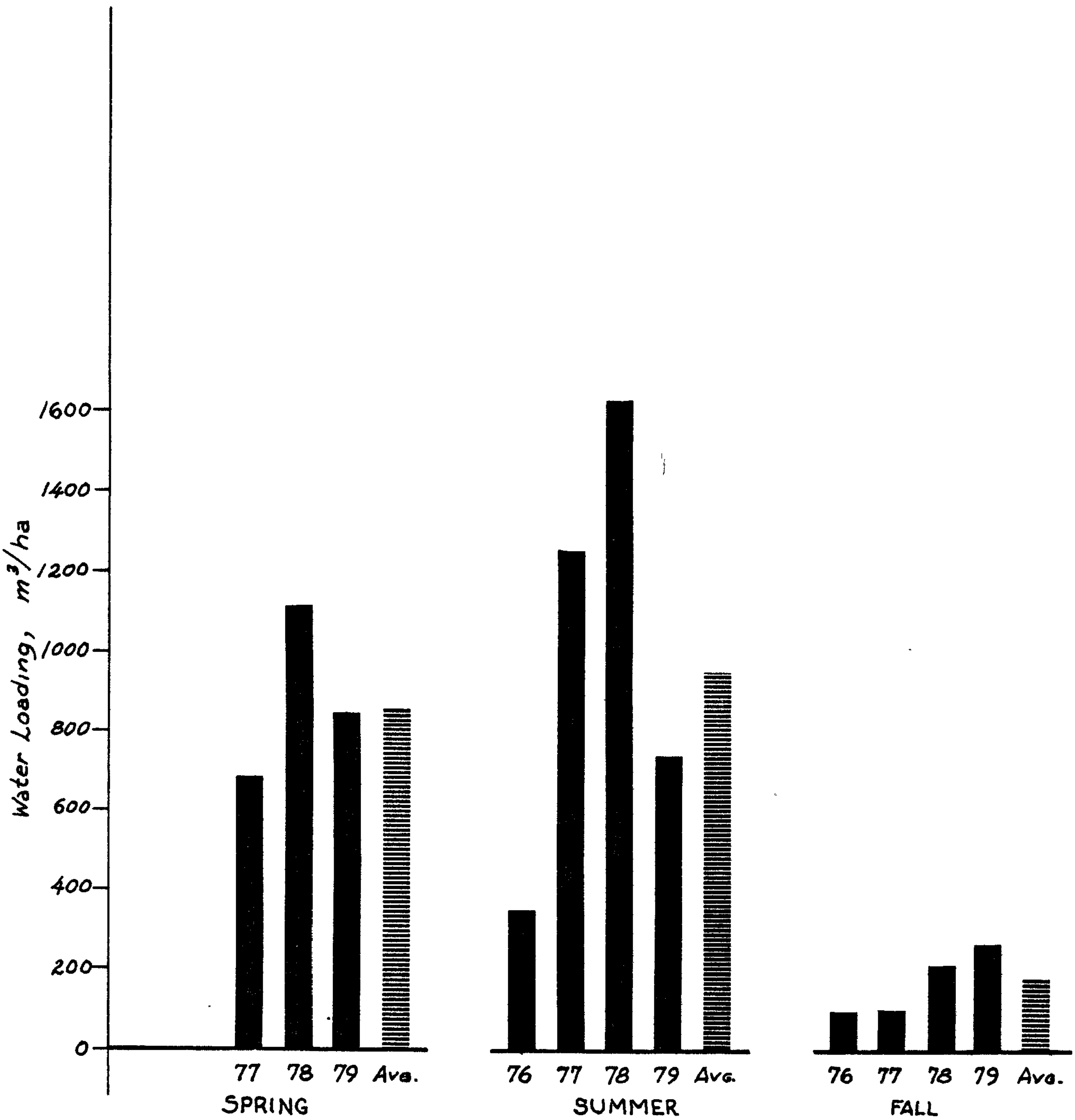

Fig. II-A-13. Seasonal event unit area loadings of water at 683089 (Brookfield).

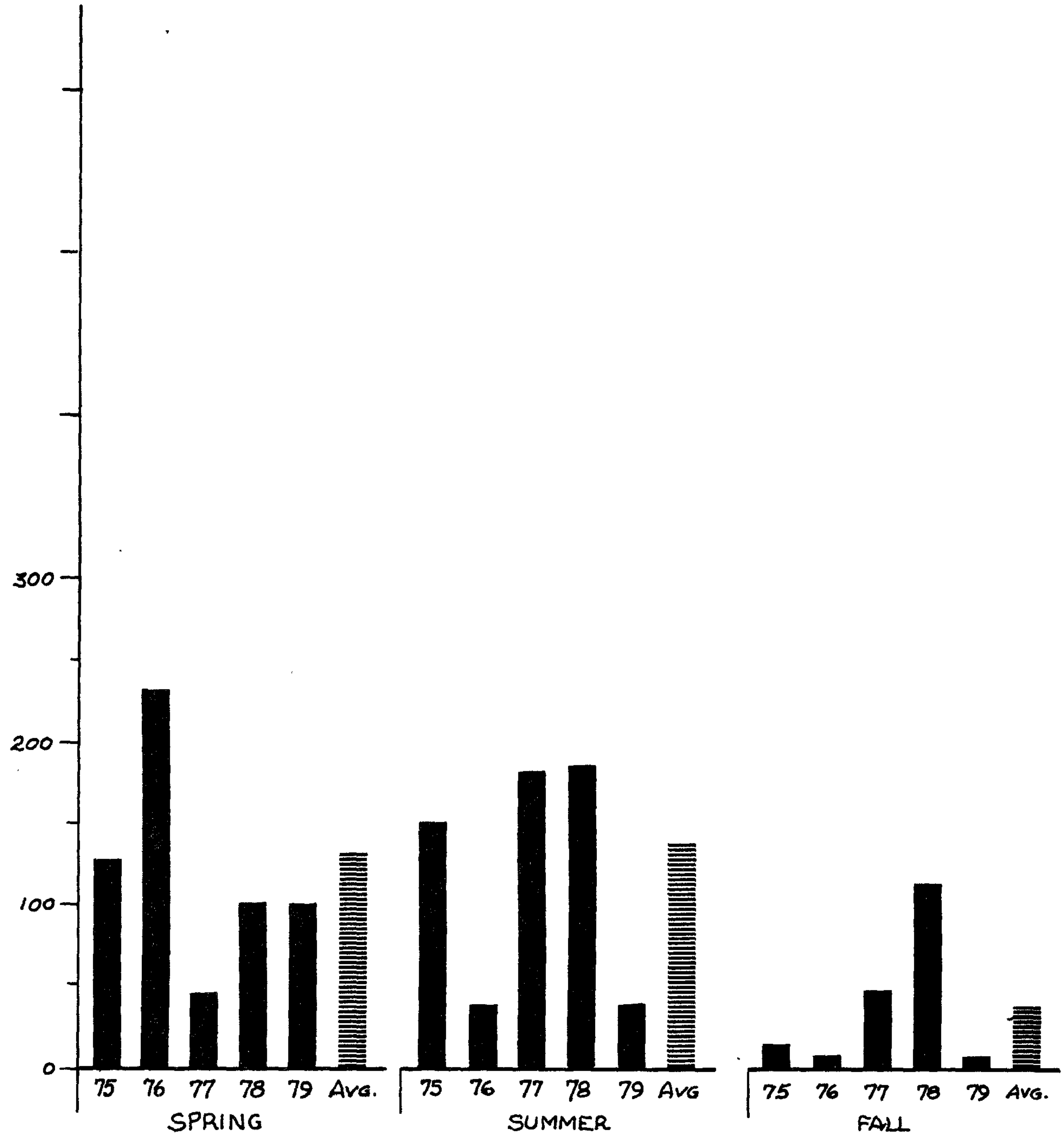

Fig. II-A-14. Seasonal event unit area loadings of suspended solids at 413005 (70th Street).

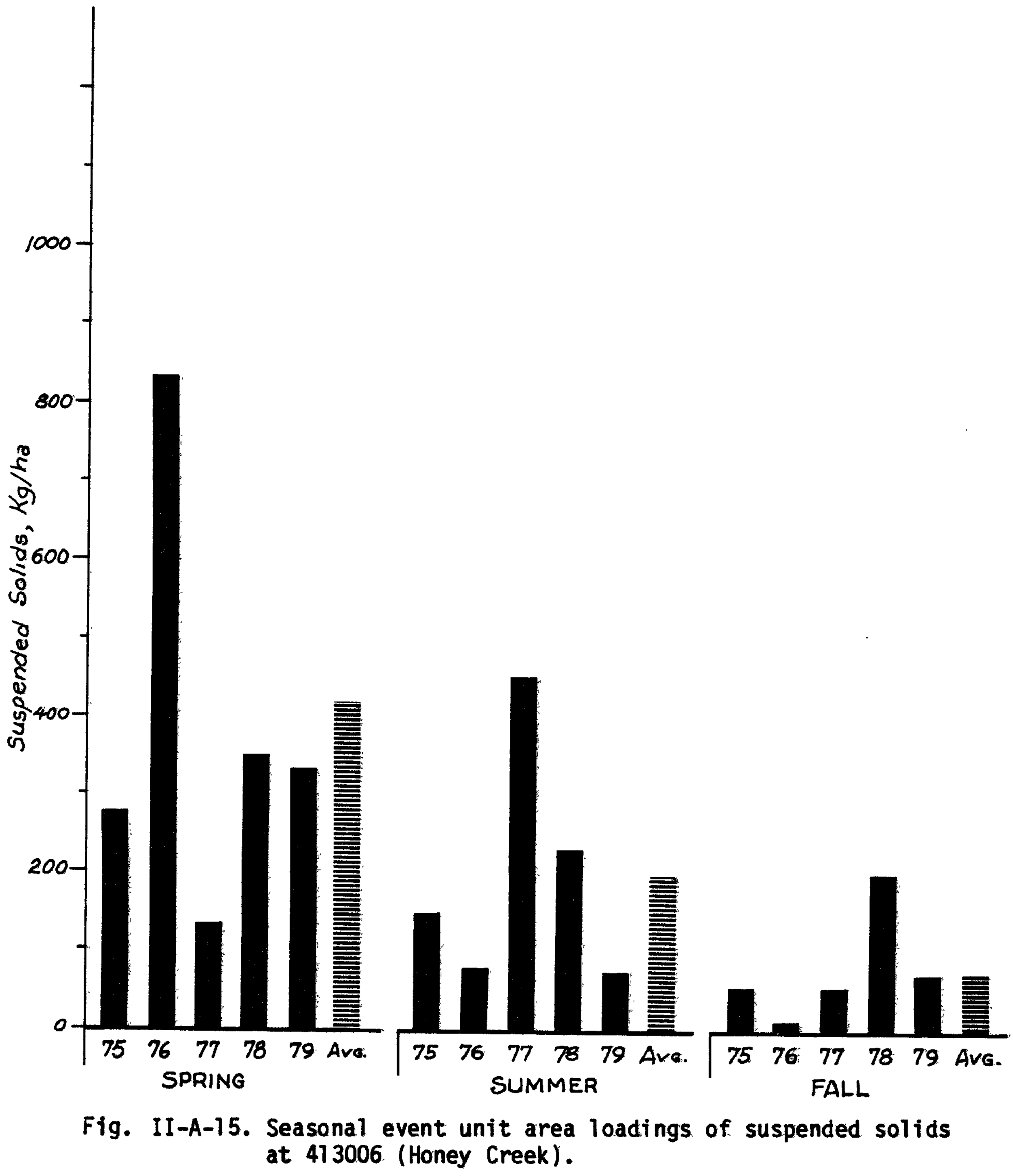

Fig. II-A-15. Seasonal event unit area loadings of suspended solids at 413006 (Honey Creek).

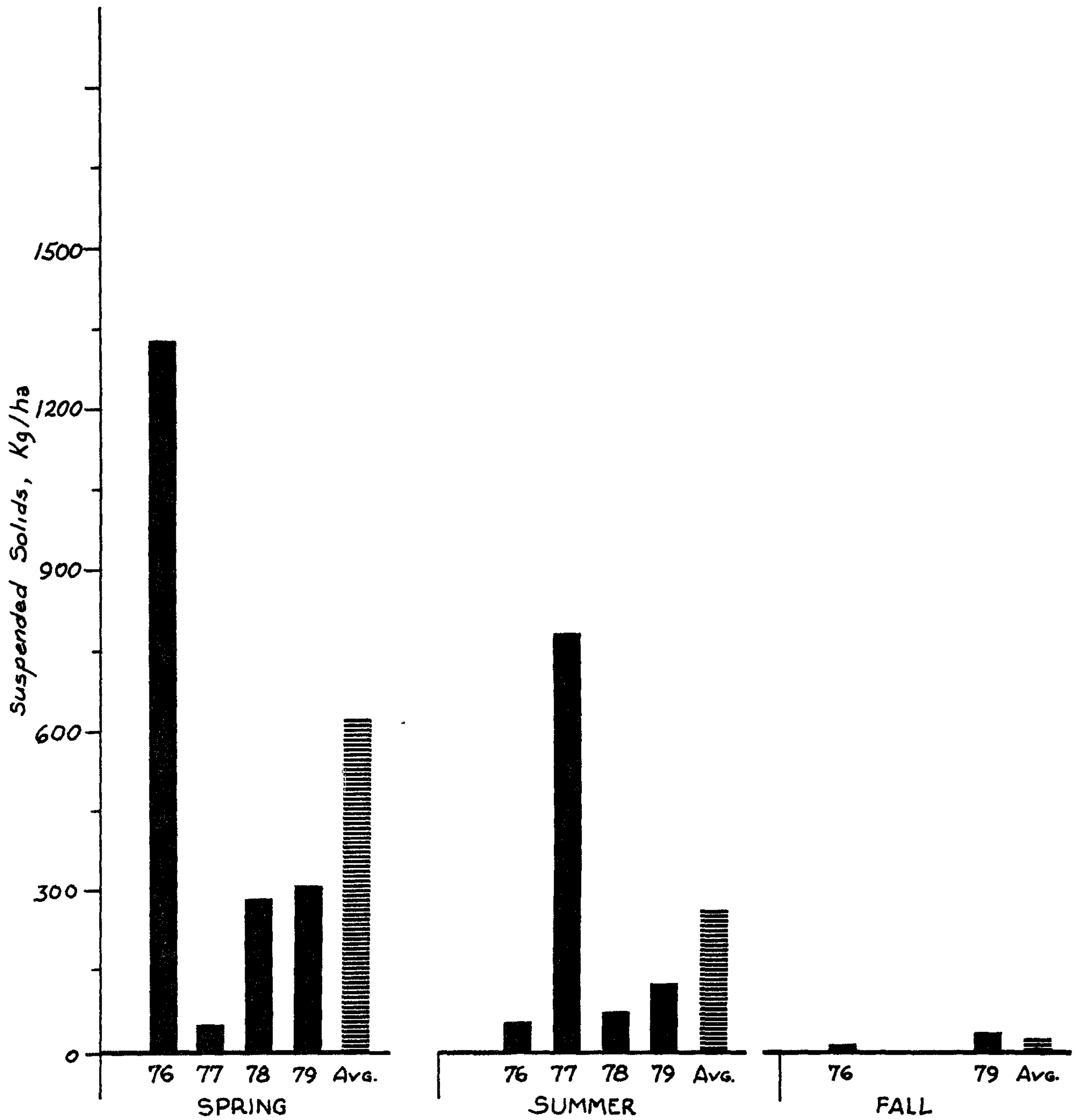

Fig. II-A-16. Seasonal event unit area loadings of suspended solids at 413011 (Noyes Creek).

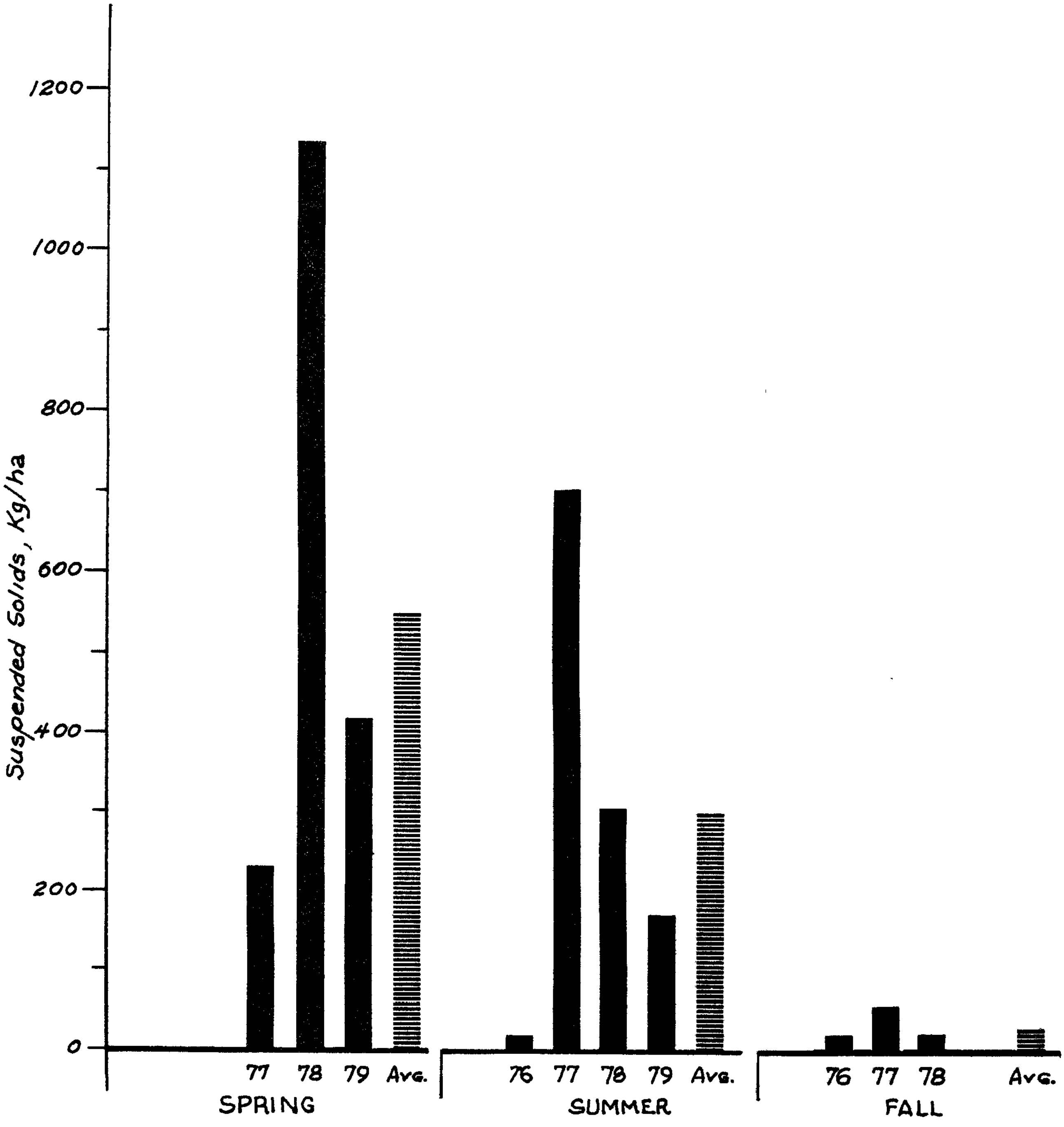

Fig. II-A-17. Seasonal event unit area loadings of suspended solids at 413615 (Stadium).

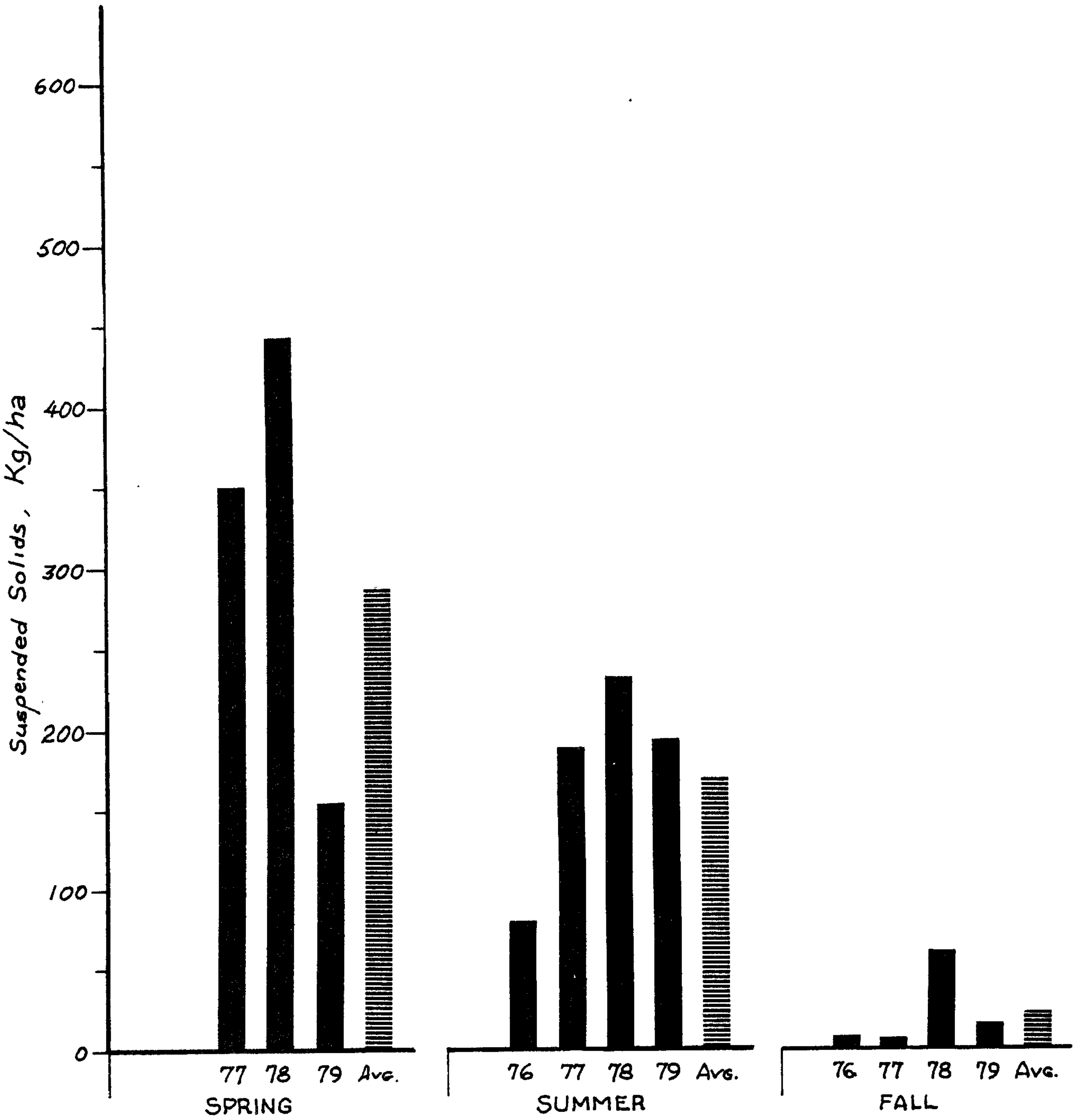

Fig. II-A-18. Seasonal event unit area loadings of suspended solids at 683089 (Brookfield).

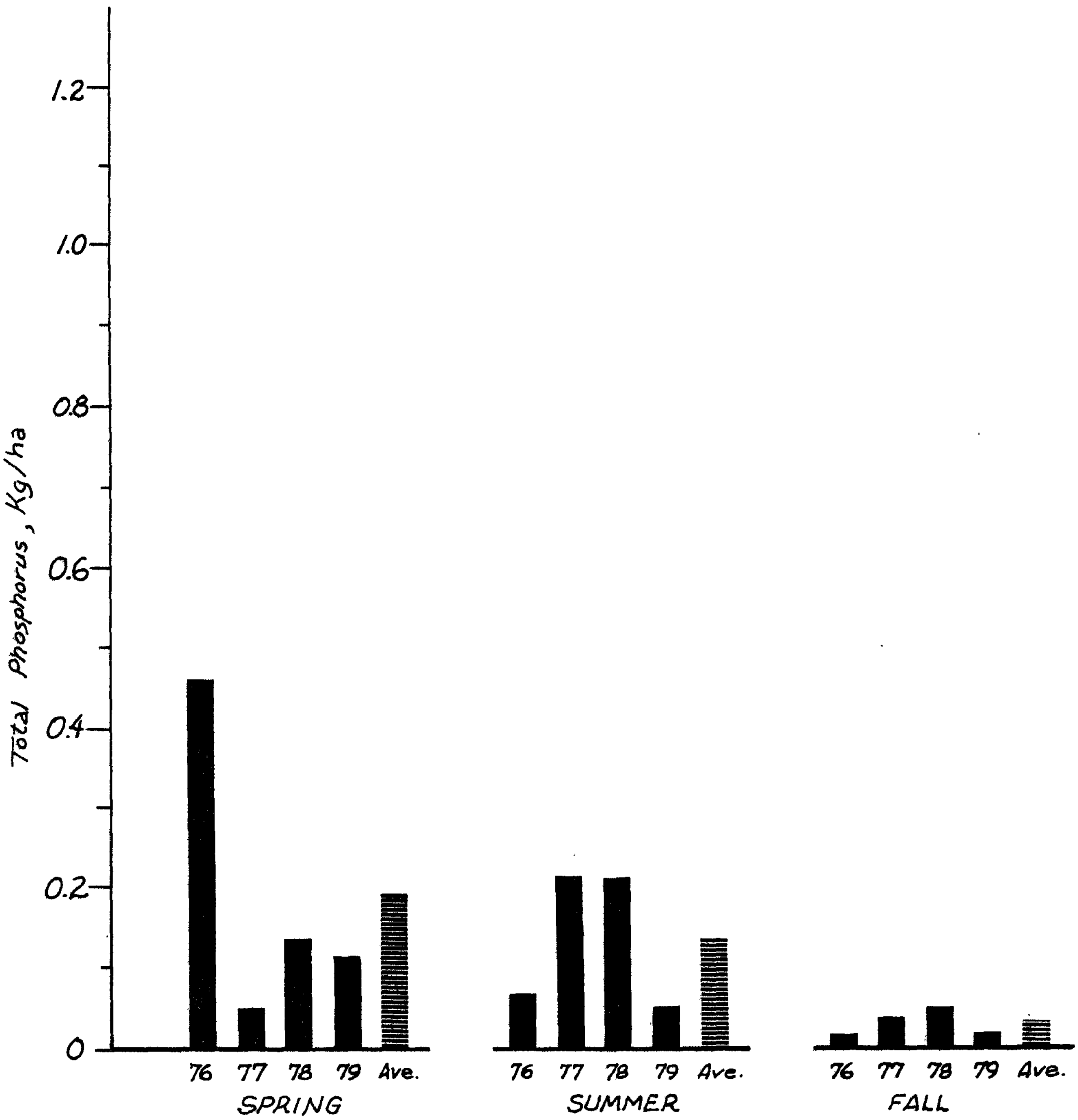

Fig. II-A-19. Seasonal event unit area loadings of total-P at 413005 (70th Street).

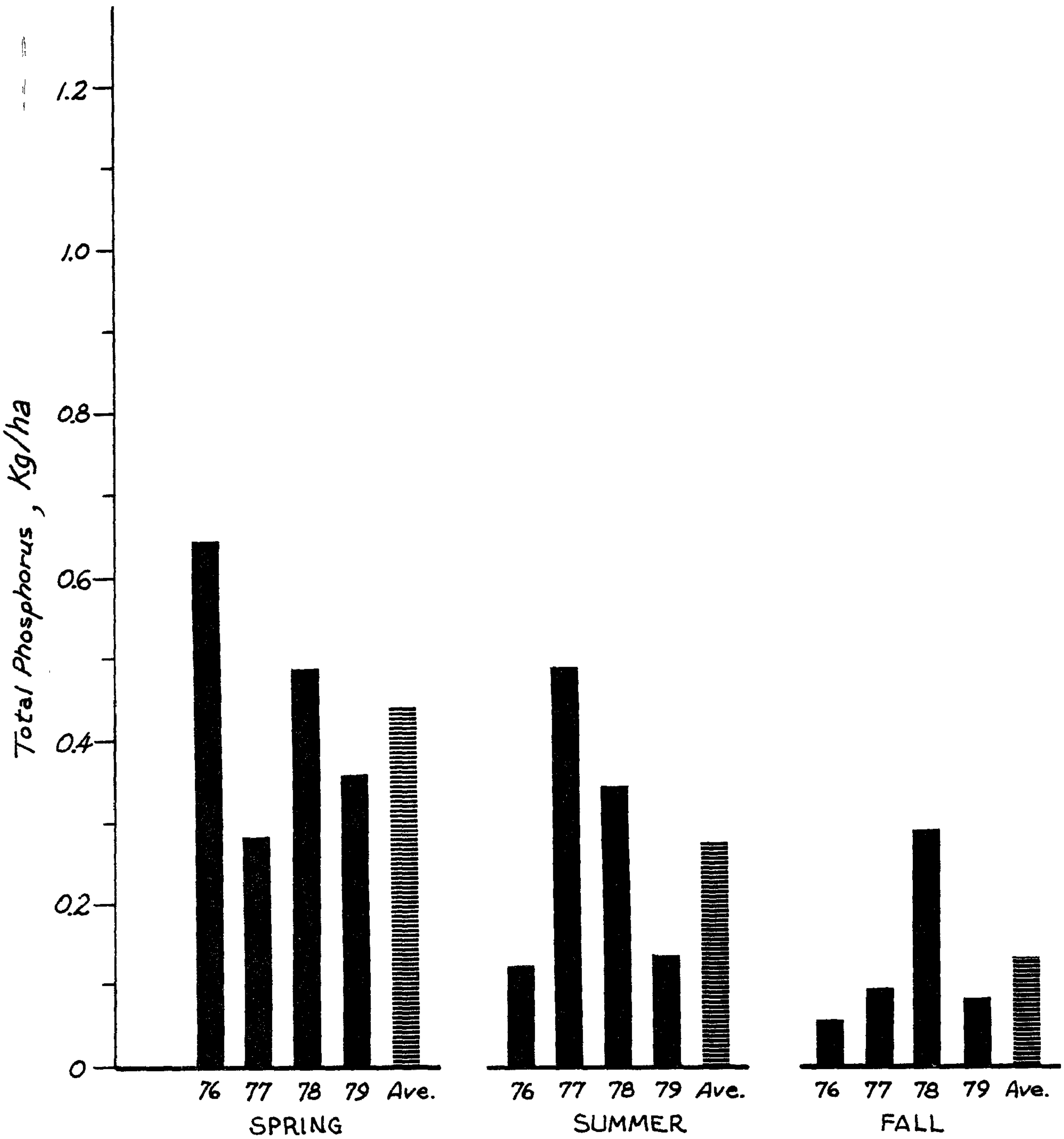

Fig. II-A-20. Seasonal event unit area loadings of total-P at 413006 (Honey Creek).

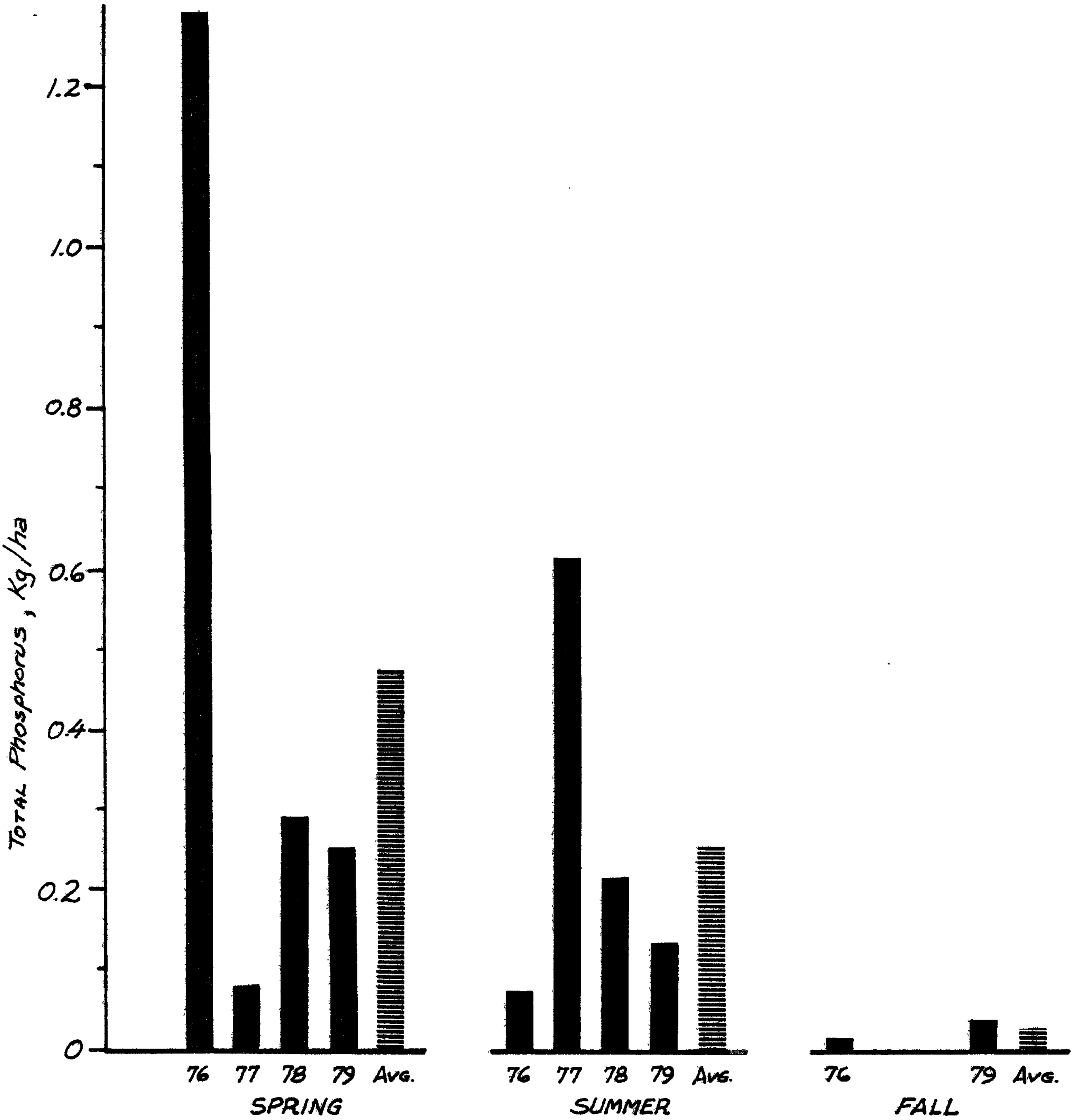

Fig. II-A-21. Seasonal event unit area loadings of total-P at 413011 (Noyes Creek).

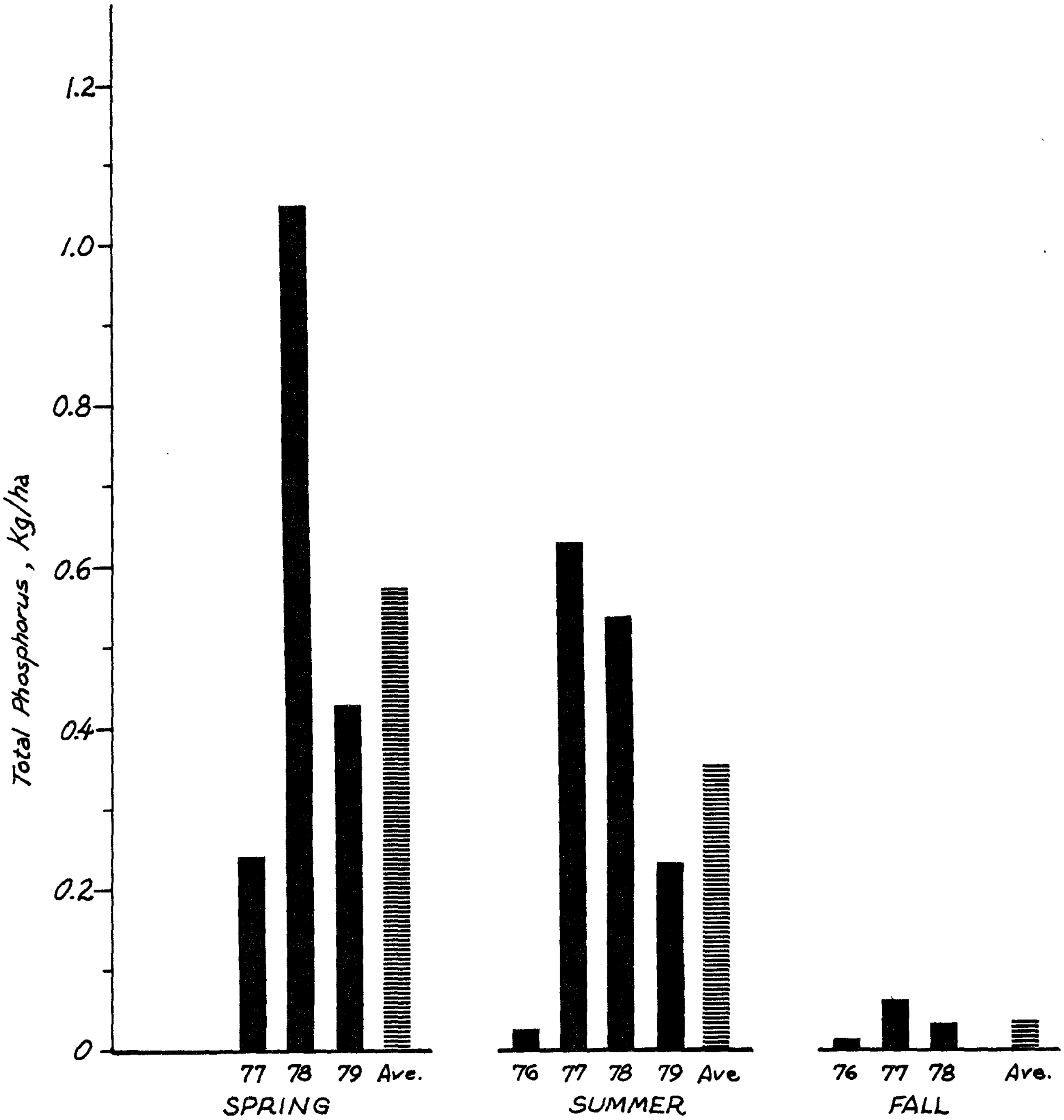

Fig. II-A-22. Seasonal event unit area loadings of total-P at 413615 (Stadium).

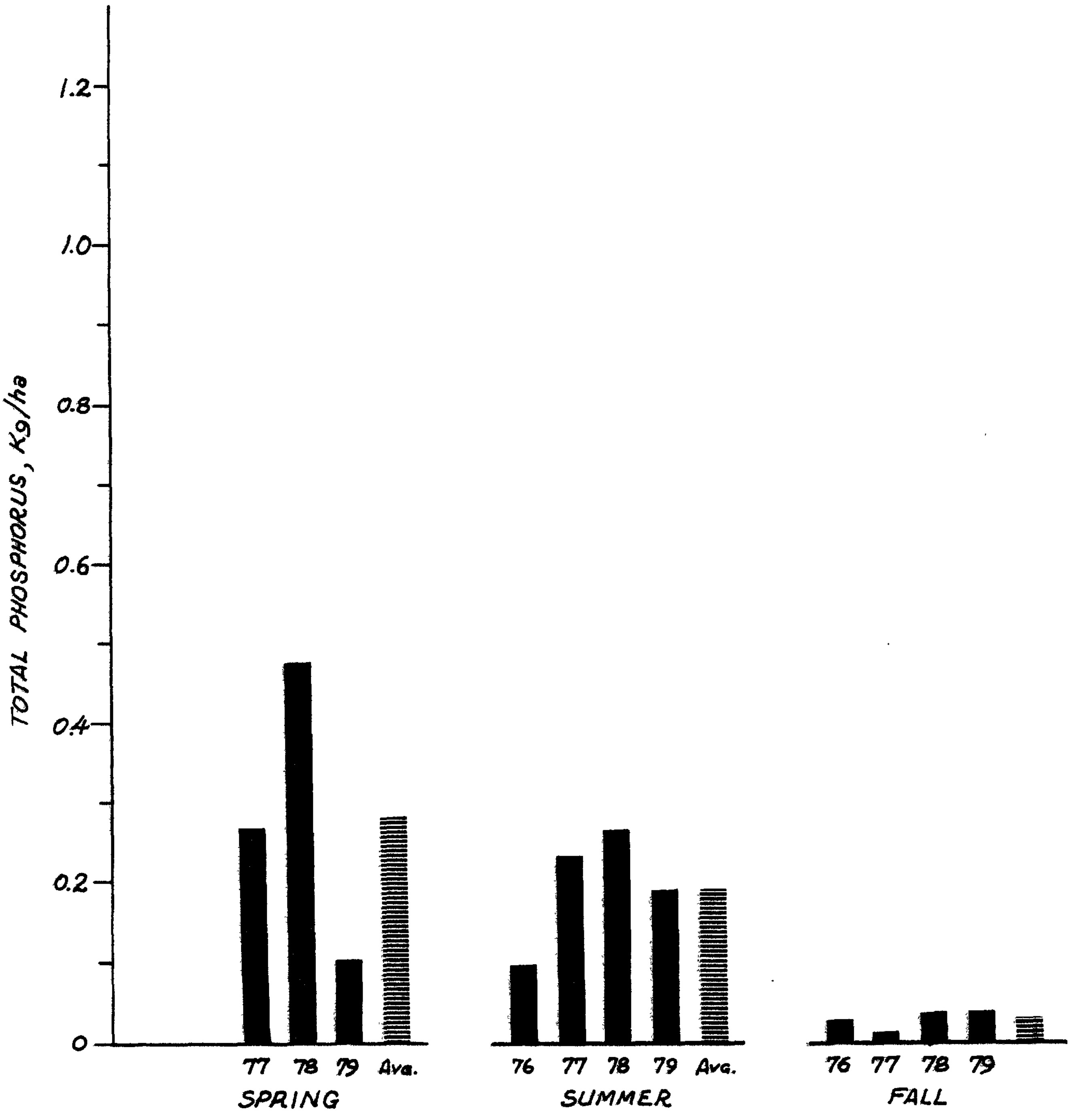

Fig. II-A-23. Seasonal event unit area loadings of total-P at 683089 (Brookfield).

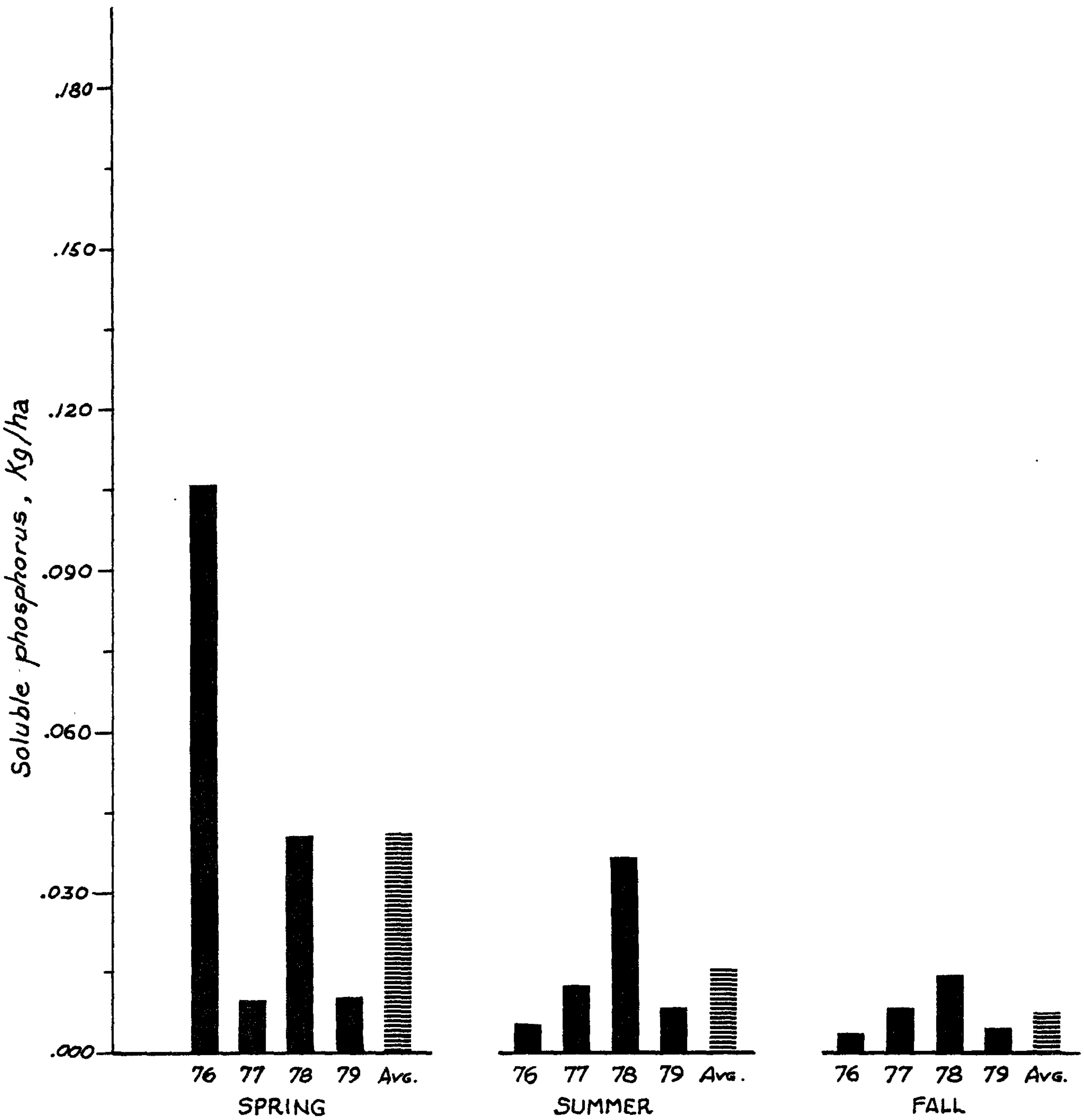

Fig. II-A-24. Seasonal event unit area loadings of soluble-P at 413005 (70th Street).

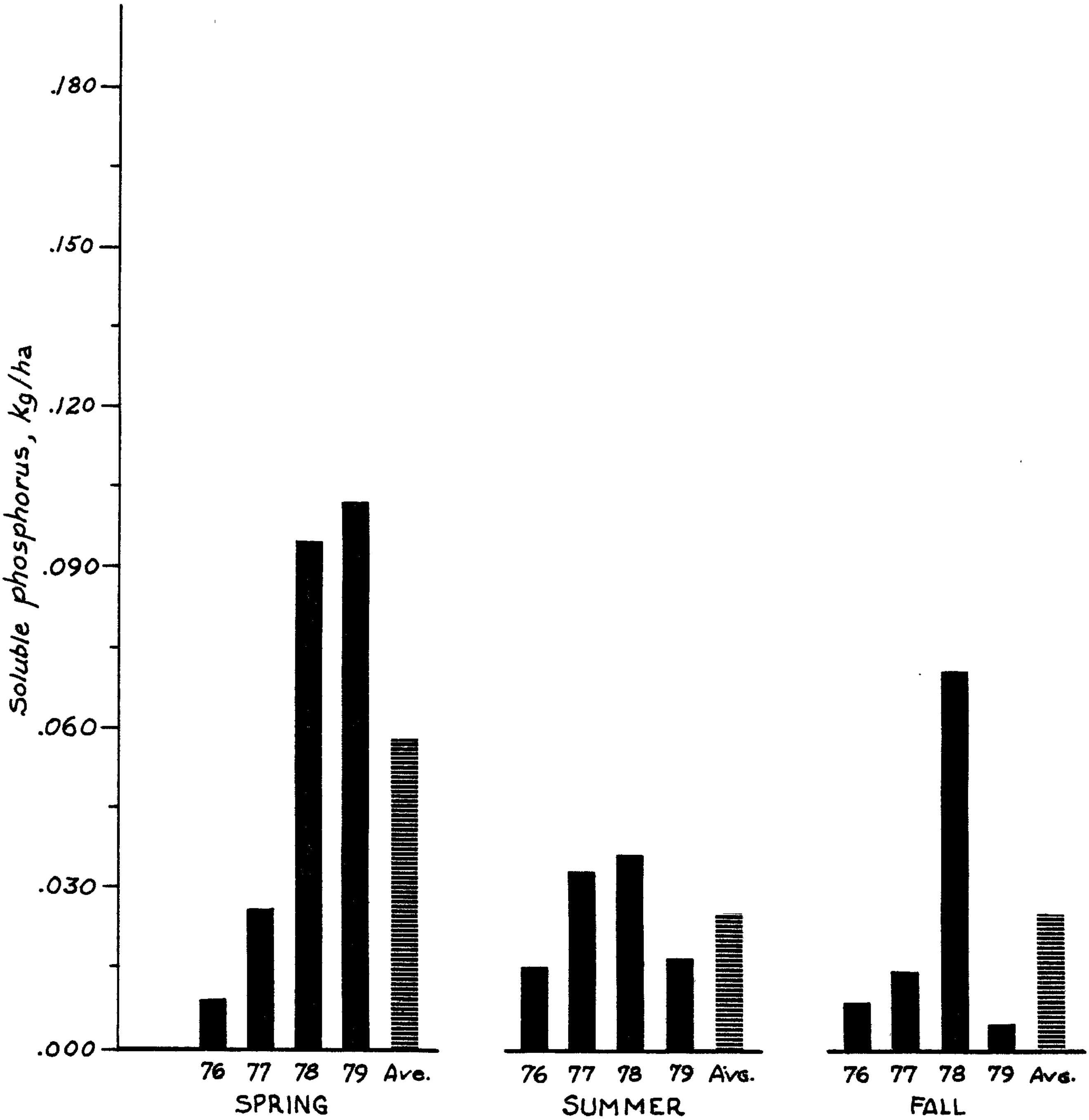

Fig. II-A-25. Seasonal event unit area loadings of soluble-P at 413006 (Honey Creek).

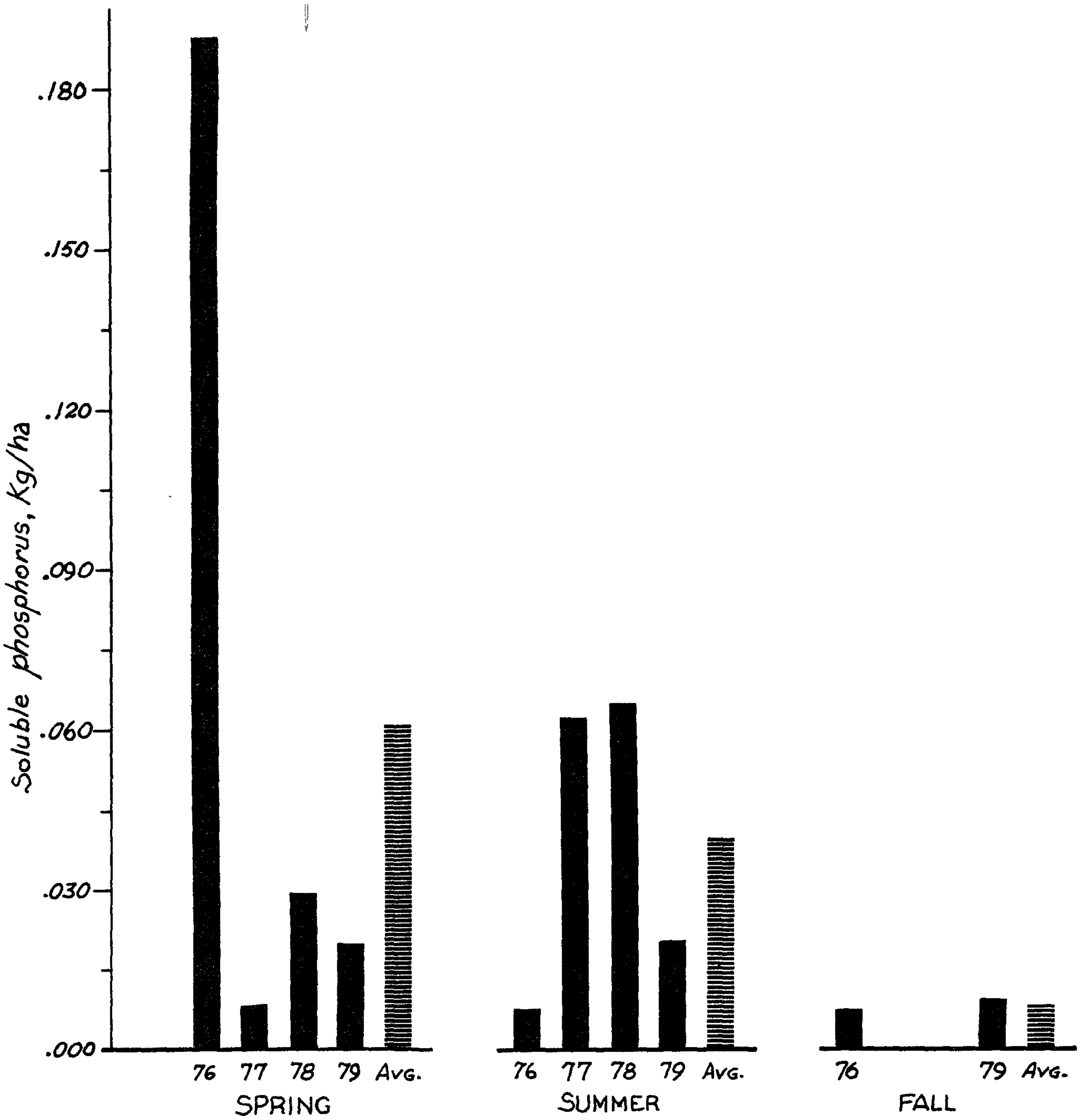

Fig. II-A-26. Seasonal event unit area loadings of soluble-P at 413011 (Noyes Creek).

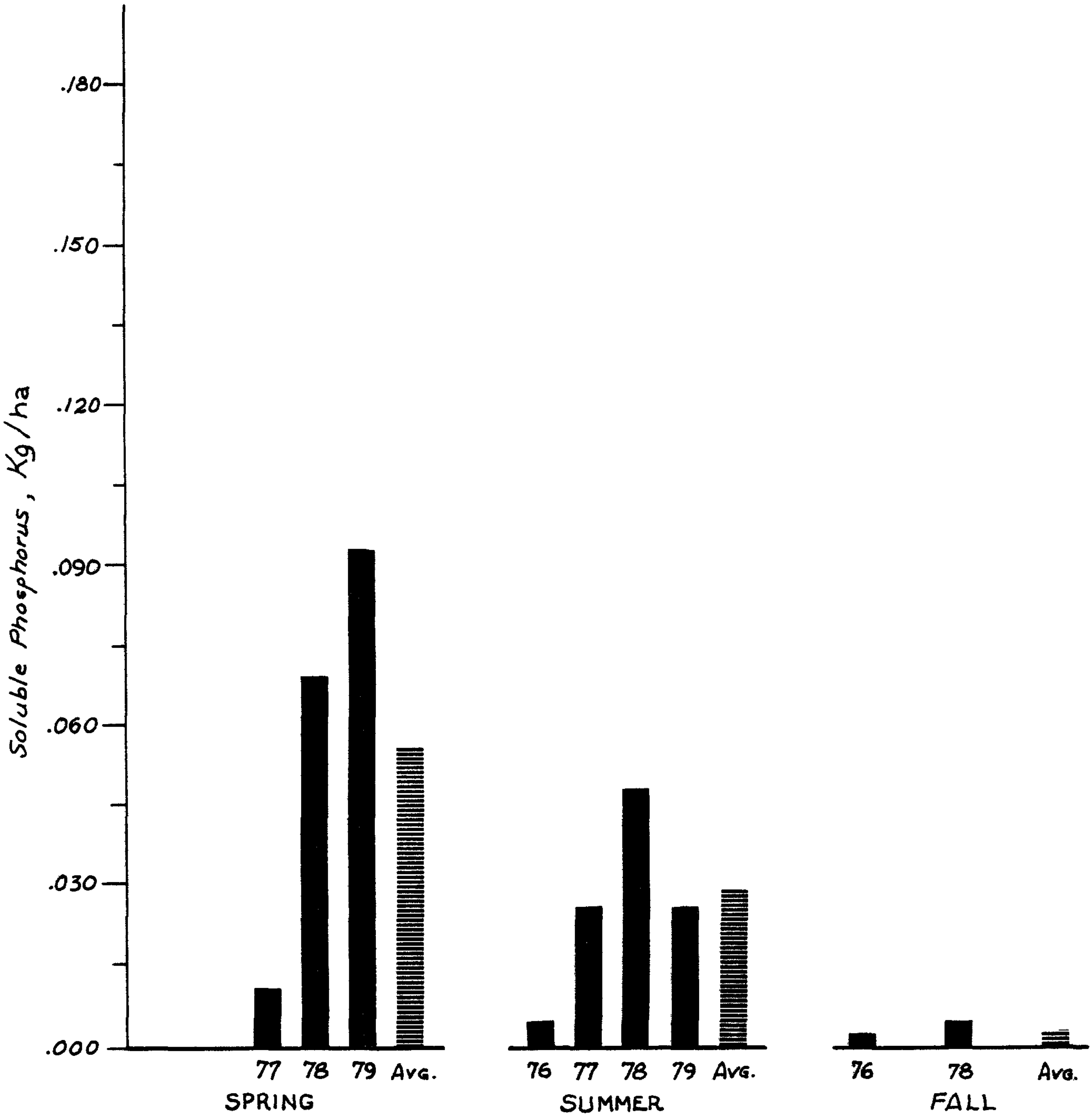

Fig. II-A-27. Seasonal event unit area loadings of soluble-P at 413615 (Stadium).

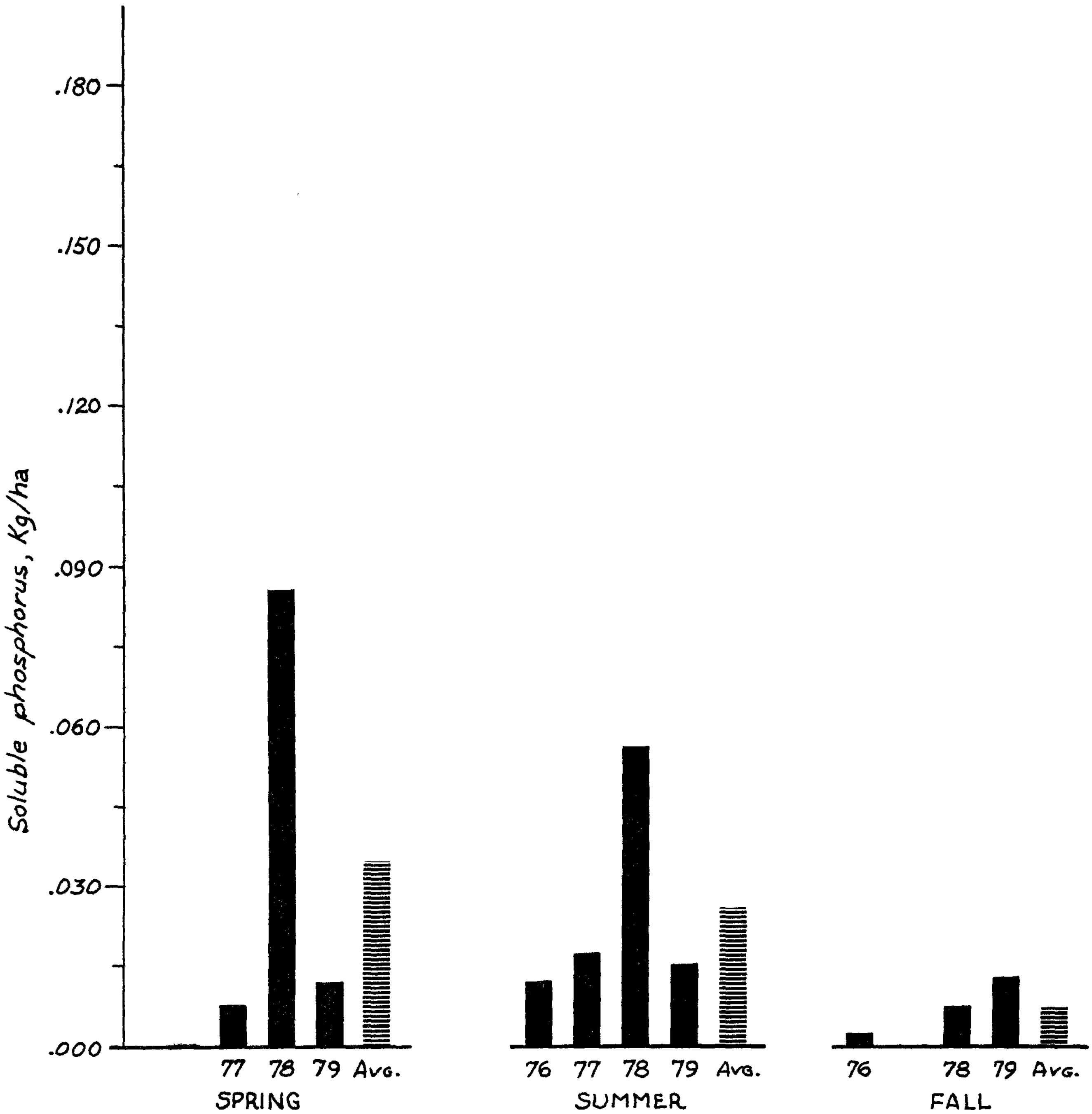

Fig. II-A-28. Seasonal event unit area loadings of soluble-P at 683089 (Brookfield).

Table II-A-9. Correlation coefficients (r) and regression equations for selected event unit area parameter loadings and percent connected imperviousness by seasons for 1976 to 1979

Year	Spring r - value (Regression equation)	Summer r - value (Regression equation)	Fall r - value (Regression equation)
		Water	
1976	0.599 (Y = 1129. + 42.9X)	0.822 (Y = 25.2 + 5.9X)	0.623 (Y = 13.3 + 1.36X)
1977	0.975 (Y = 64.2 + 9.40X)	0.969 (Y = 41.3 + 31.7X)	0.611 (Y = 59.2 + 2.43)
1978	0.931 (Y = 34.2 + 36.8X)	0.892 (Y = 366. + 27.2X)	0.967 (Y = 27.1 + 3.66X)
1979	0.925 (Y = 388. + 28.9X)	0.936 (Y = 14.8 + 16.6X)	0.791 (Y = 18.3 + 4.03X)
		Suspended Solids	
1976	0.504 (Y = 164. + 19.5X)	0.934 (Y = 10.0 + 2.11X)	0.274 (Y = 3.73 + .0463X)
1977	0.907 (Y = -9.40 + 4.83X)	0.913 (Y = 32.7 + 12.9X)	0.127 (Y = 23. + .147X)
1978	0.839 (Y = -16.1 + 18.0X)	0.422 (Y = 140. + 1.82X)	0.012 (Y = 77.6 + .0486X)
1979	0.971 (Y = 75.7 + 8.1X)	0.948 (Y = 8.34 + 3.47X)	0.439 (Y = 5.58 + .735X)
		Total P	
1976	0.259 (Y = .475 + .0072X)	0.545 (Y = .0215 + .0016X)	0.555 (Y = .0054 + .0005X)
1977	0.813 (Y = .0194 + .0057X)	0.936 (Y = .0748 + .0120X)	0.269 (Y = .0259 + .0004X)
1978	0.904 (Y = .037 + .0182X)	0.715 (Y = .175 + .0058X)	0.129 (Y = .0619 + .0007X)
1979	0.702 (Y = .187 + .0045X)	0.983 (Y = .01 + .0048X)	0.693 (Y = .0094 + .0011X)

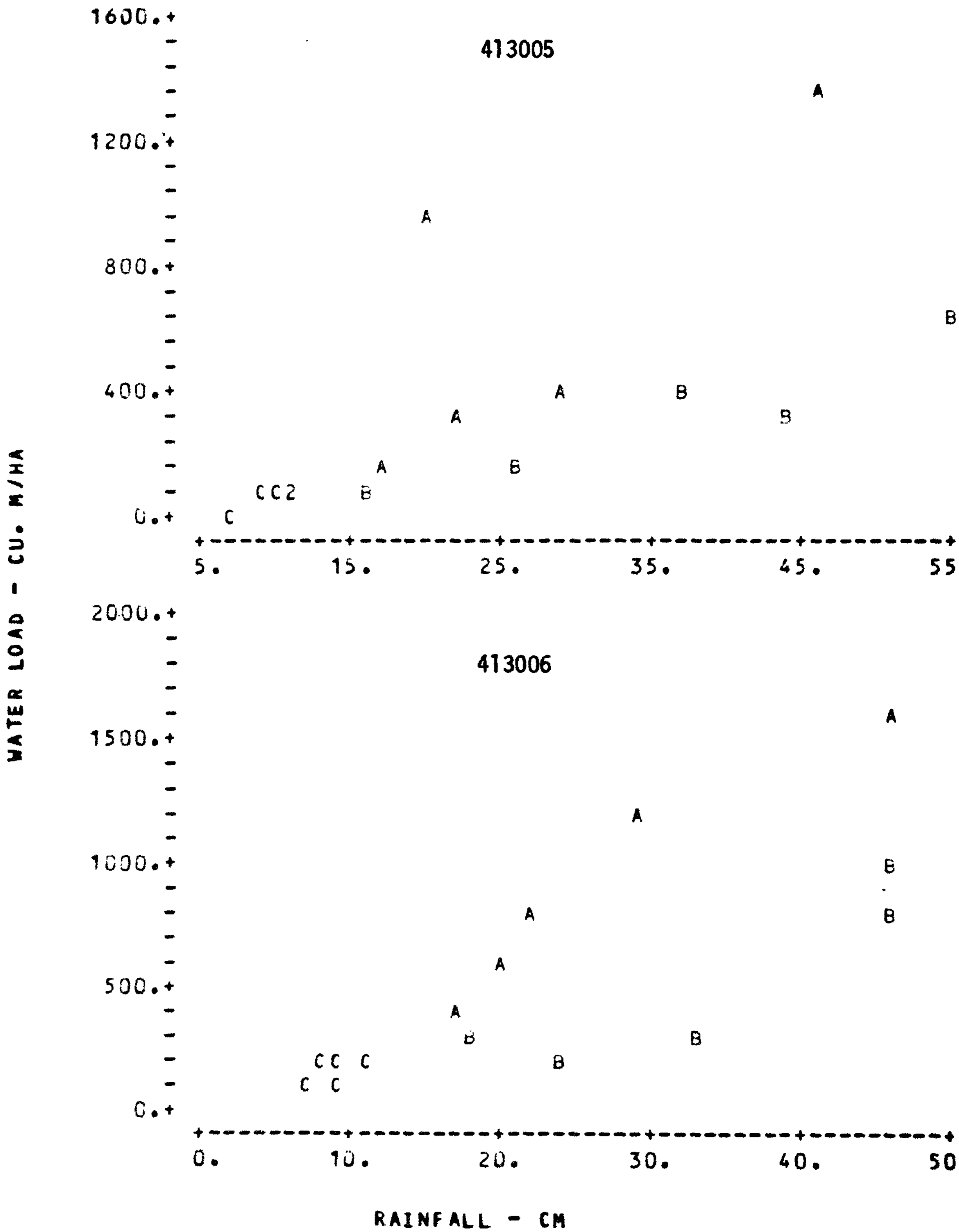

Fig. II-A-29. Relationship of seasonal event unit area water loadings and rainfall at 70th St. (413005) and Honey Creek (413006).(A = Spring, B = Summer, C = Fall)

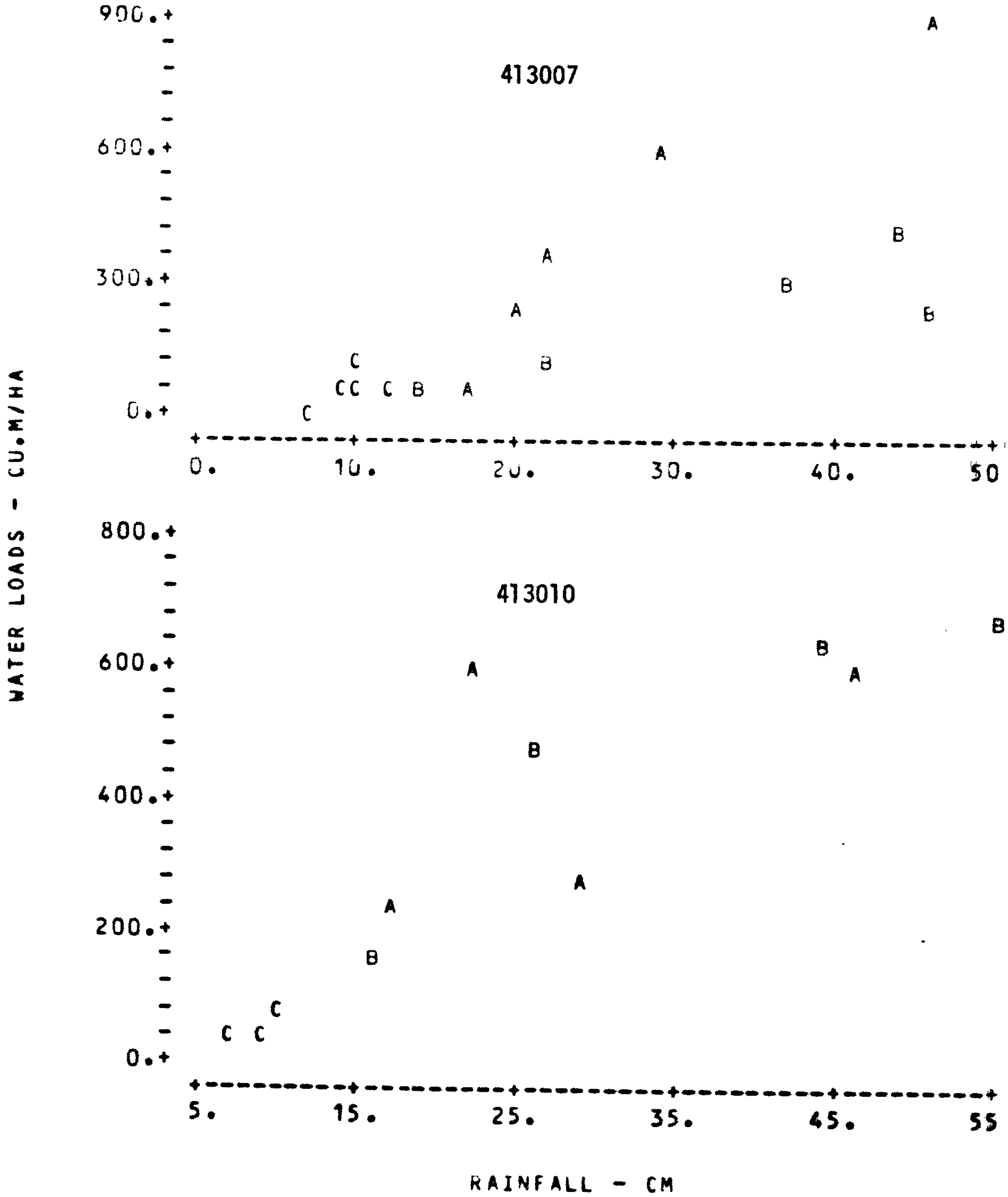

Fig. II-A-30. Relationship of seasonal event unit area water loadings and rainfall at Underwood creek (413007) and Schoonmaker Creek (413010). (A = Spring, B = Summer, C = Fall)

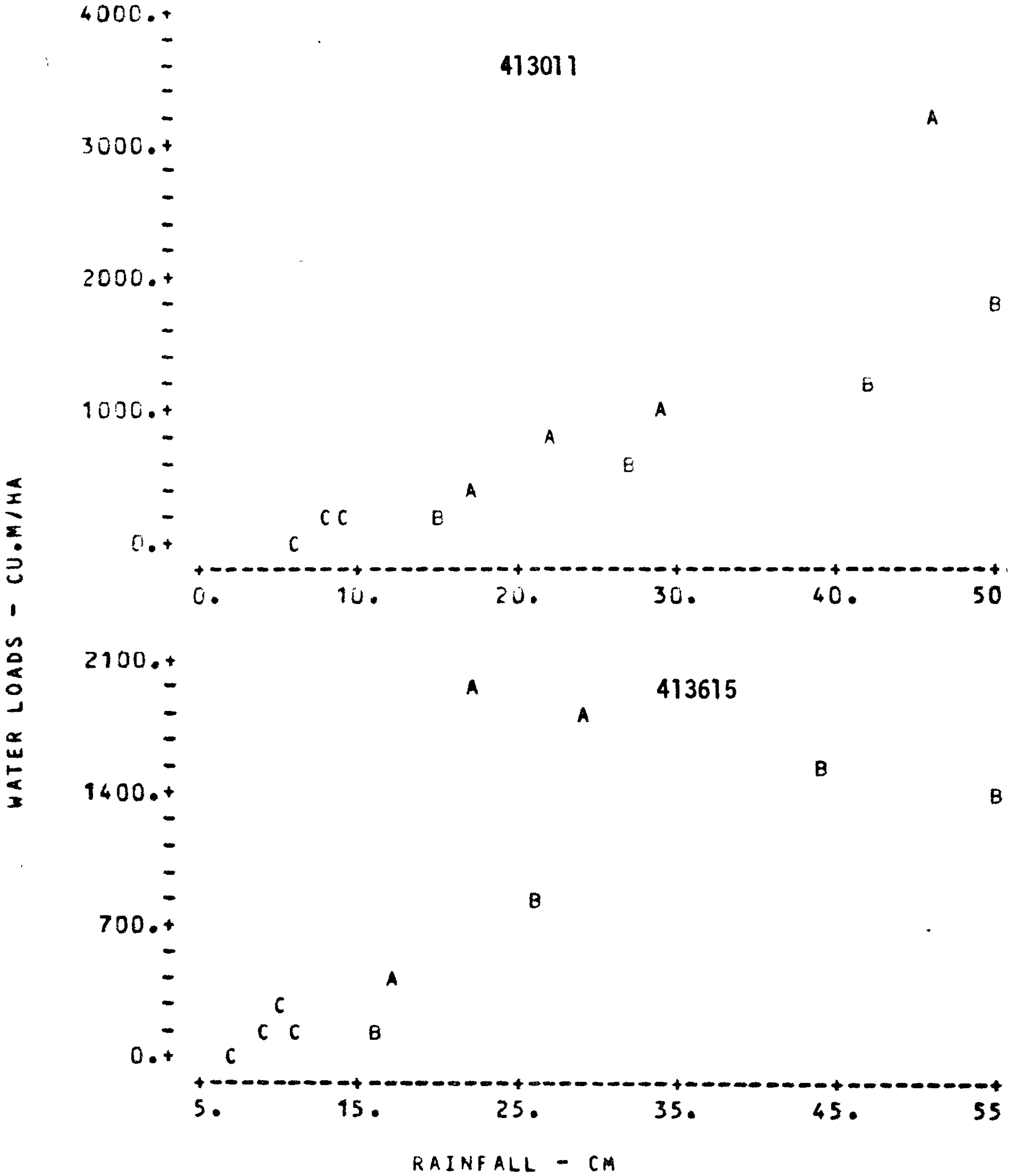

Fig. II-A-31. Relationship of seasonal event unit area water loadings and rainfall at Noyes Creek (413011) and Stadium Interchange (413615). (A = Spring, B = Summer, C = Fall)

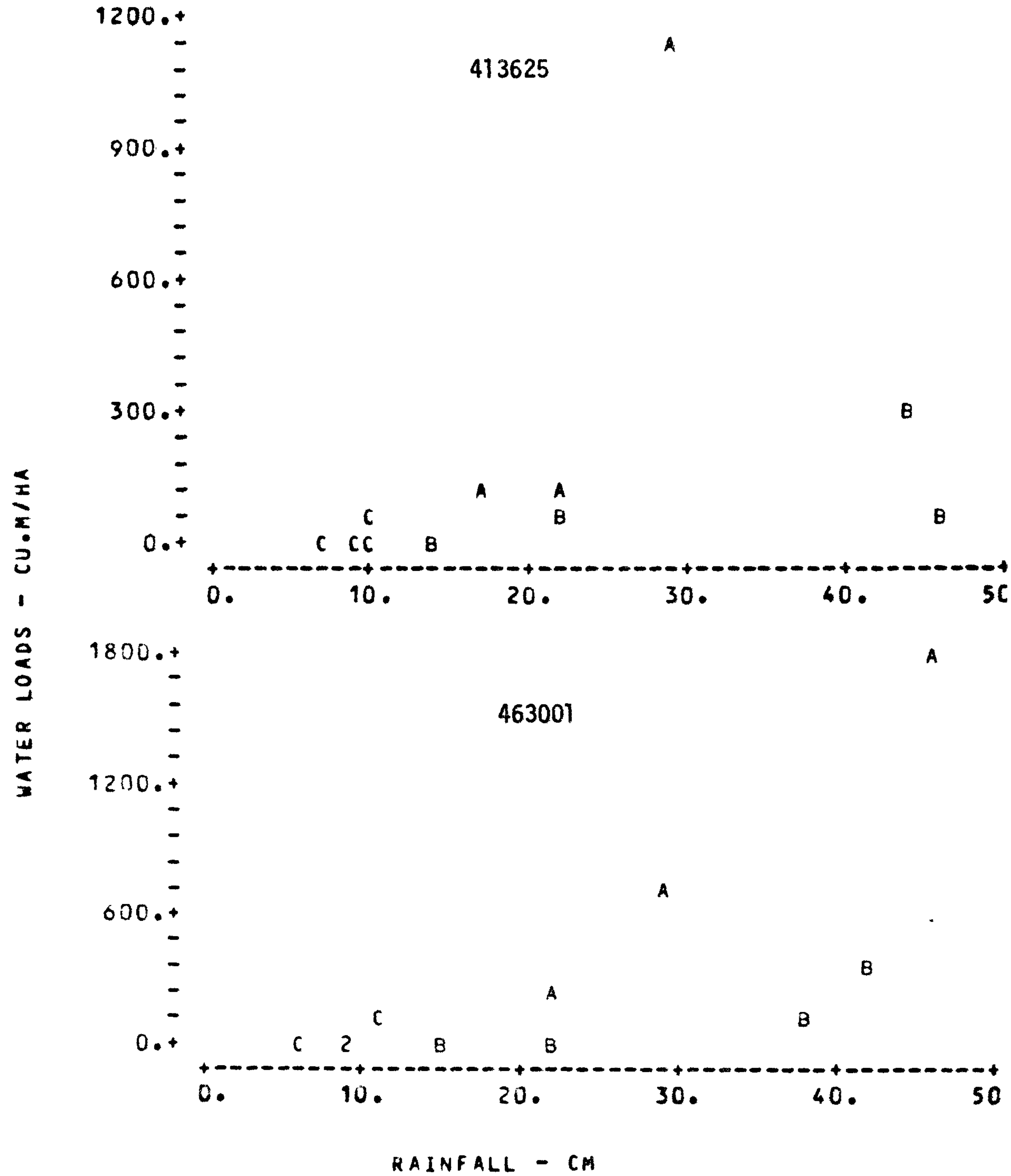

Fig. II-A-32. Relationship of seasonal event unit area water loadings and rainfall at New Berlin (413625) and Donges Bay Rd. (463001). (A = Spring, B = Summer, C = Fall)

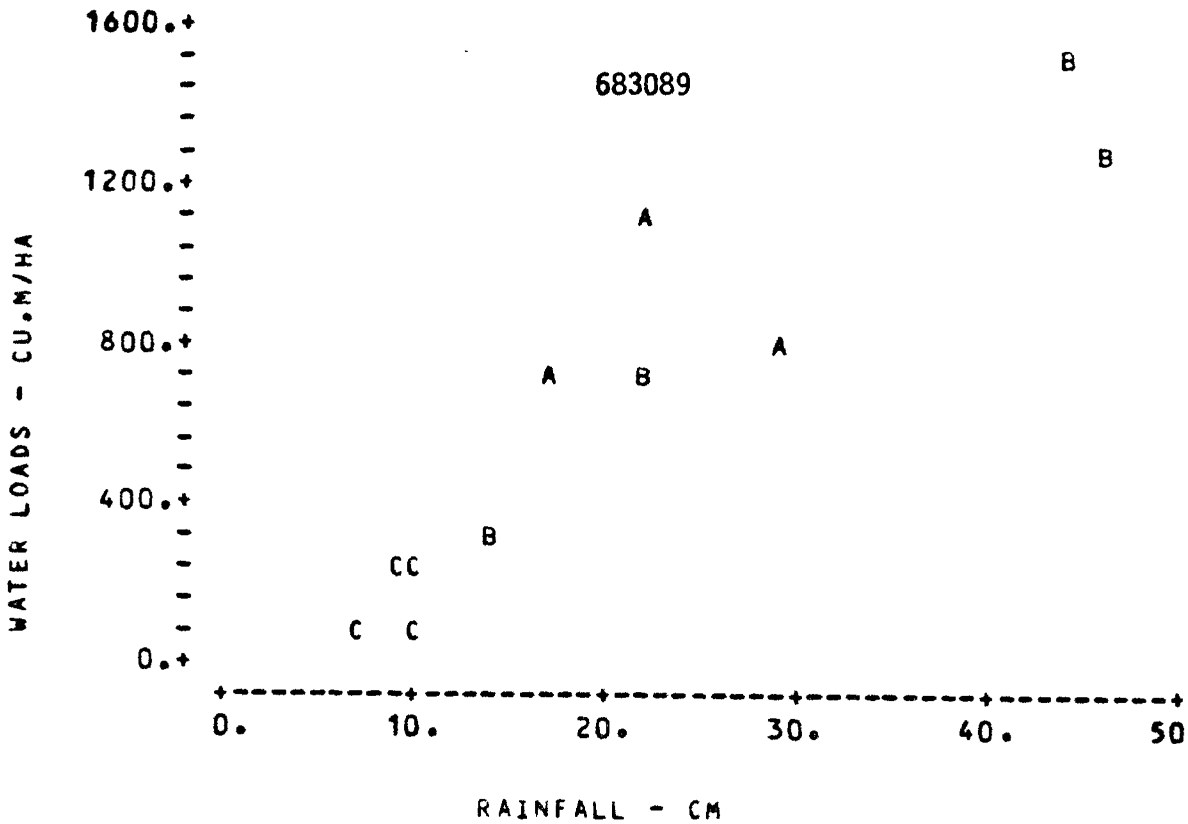

Fig. II-A-33. Relationship of seasonal event unit area water loadings and rainfall at Brookfield Square (683089). (A = Spring, B = Summer, C = Fall)

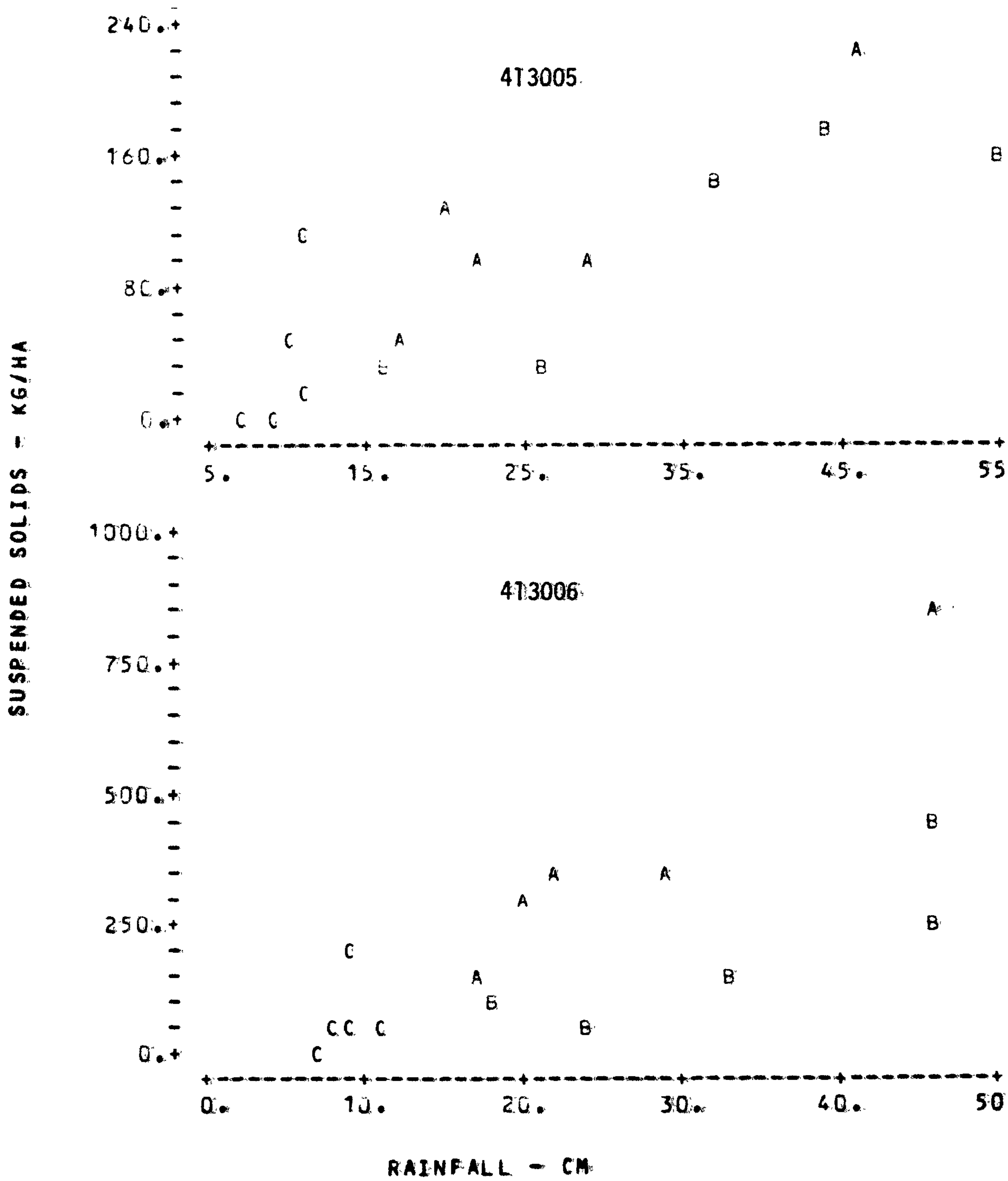

Fig. II-A-34. Relationship of seasonal event unit area suspended solids loadings and rainfall at 70th St. (413005) and Honey Creek (413006). (A = Spring, B = Summer, C = Fall)

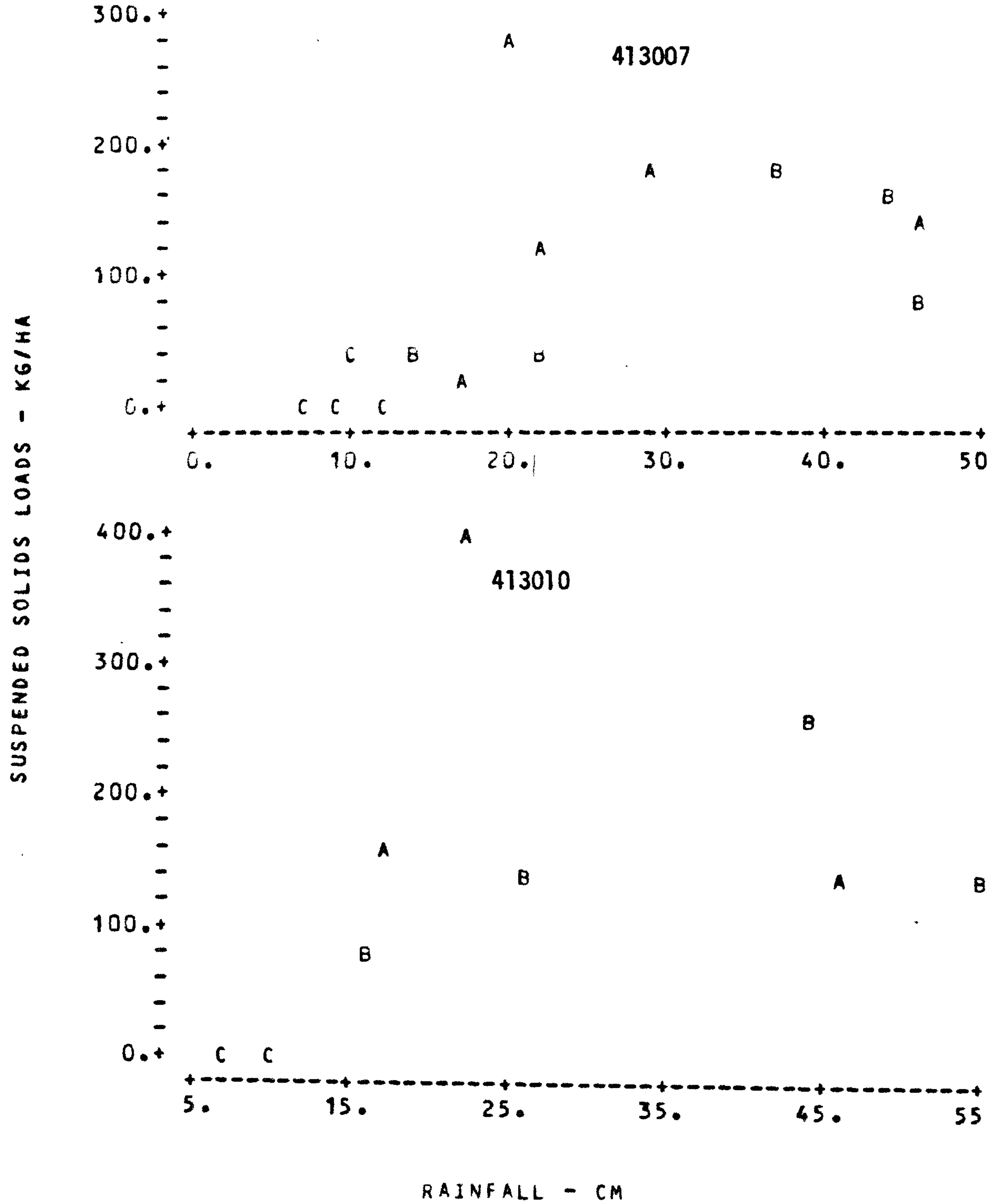

Fig. II-A-35. Relationship of seasonal event unit area suspended solids loadings and rainfall at Underwood Creek (413007) and Schoonmaker Creek (413010). (A = Spring, B = Summer, C = Fall)

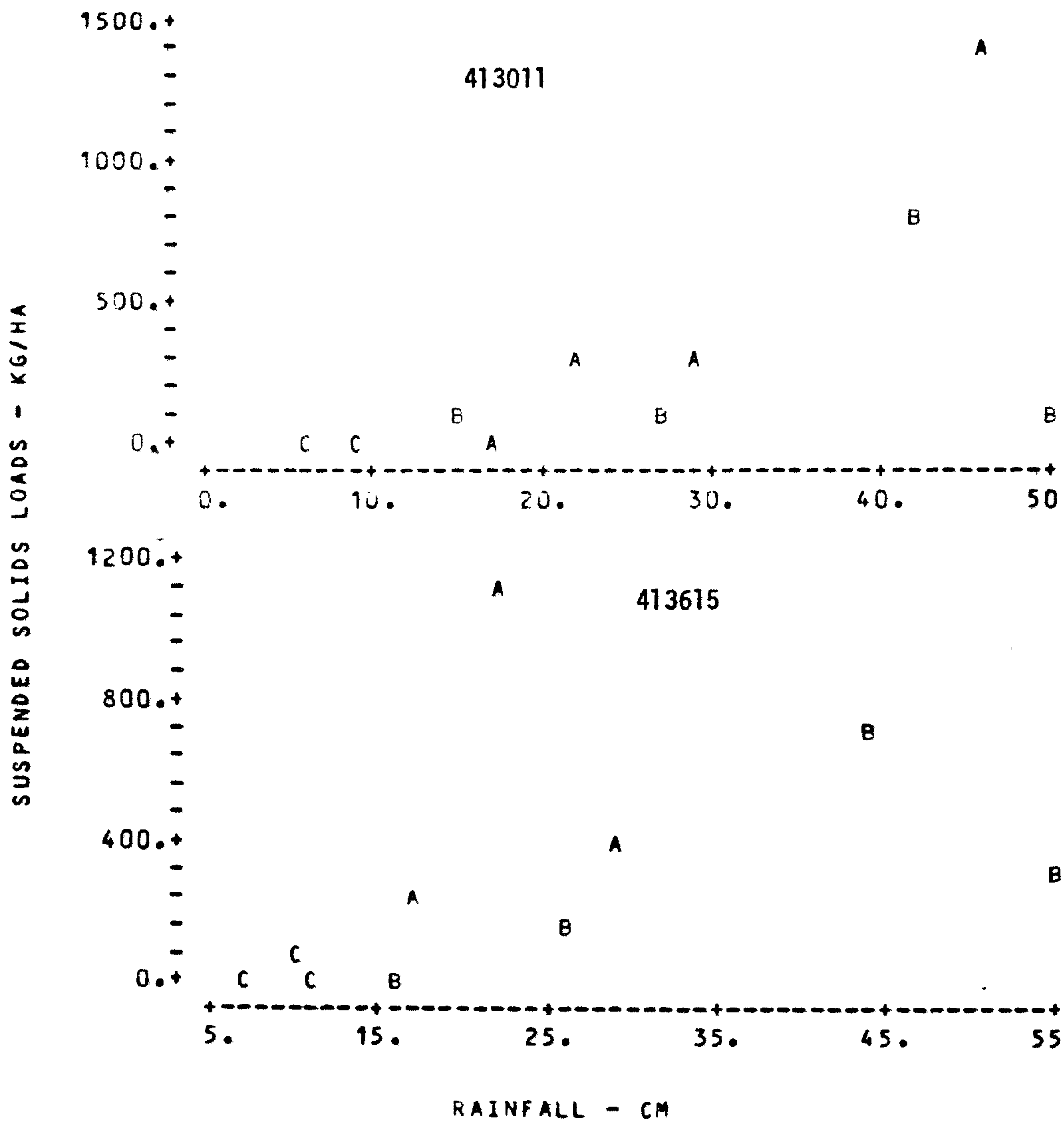

Fig. II-A-36. Relationship of seasonal event unit area suspended solids loadings and rainfall at Noyes Creek (413011) and Stadium (413615). (A = Spring, B = Summer, C = Fall)

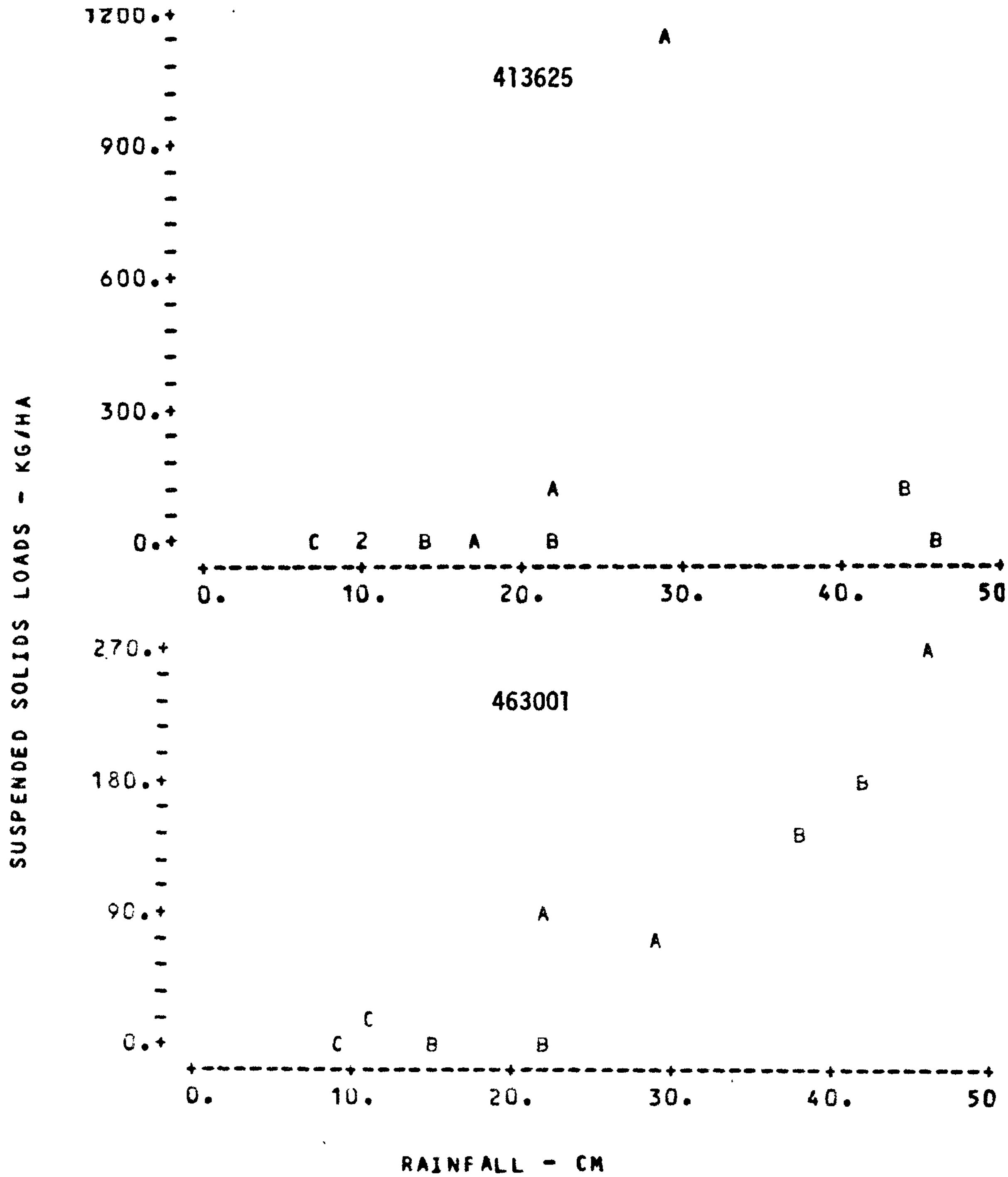

Fig. II-A-37. Relationship of seasonal event unit area suspended solids loadings and rainfall at New Berlin (413625) and Donges Bay Rd. (463001).
(A = Spring, B = Summer, C = Fall)

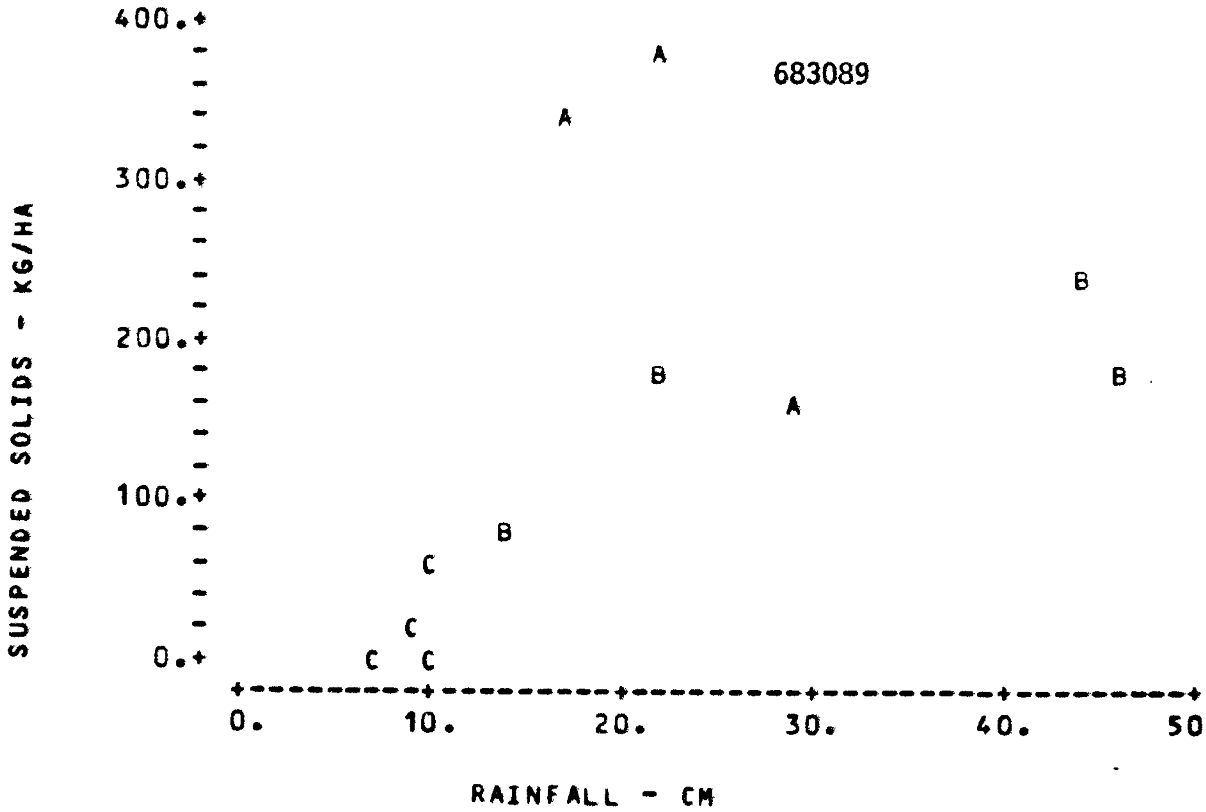

Fig. II-A-38. Relationship of seasonal event unit area suspended solids loadings and rainfall at Brookfield Square (683089). (A = Spring, B = Summer, C = Fall)

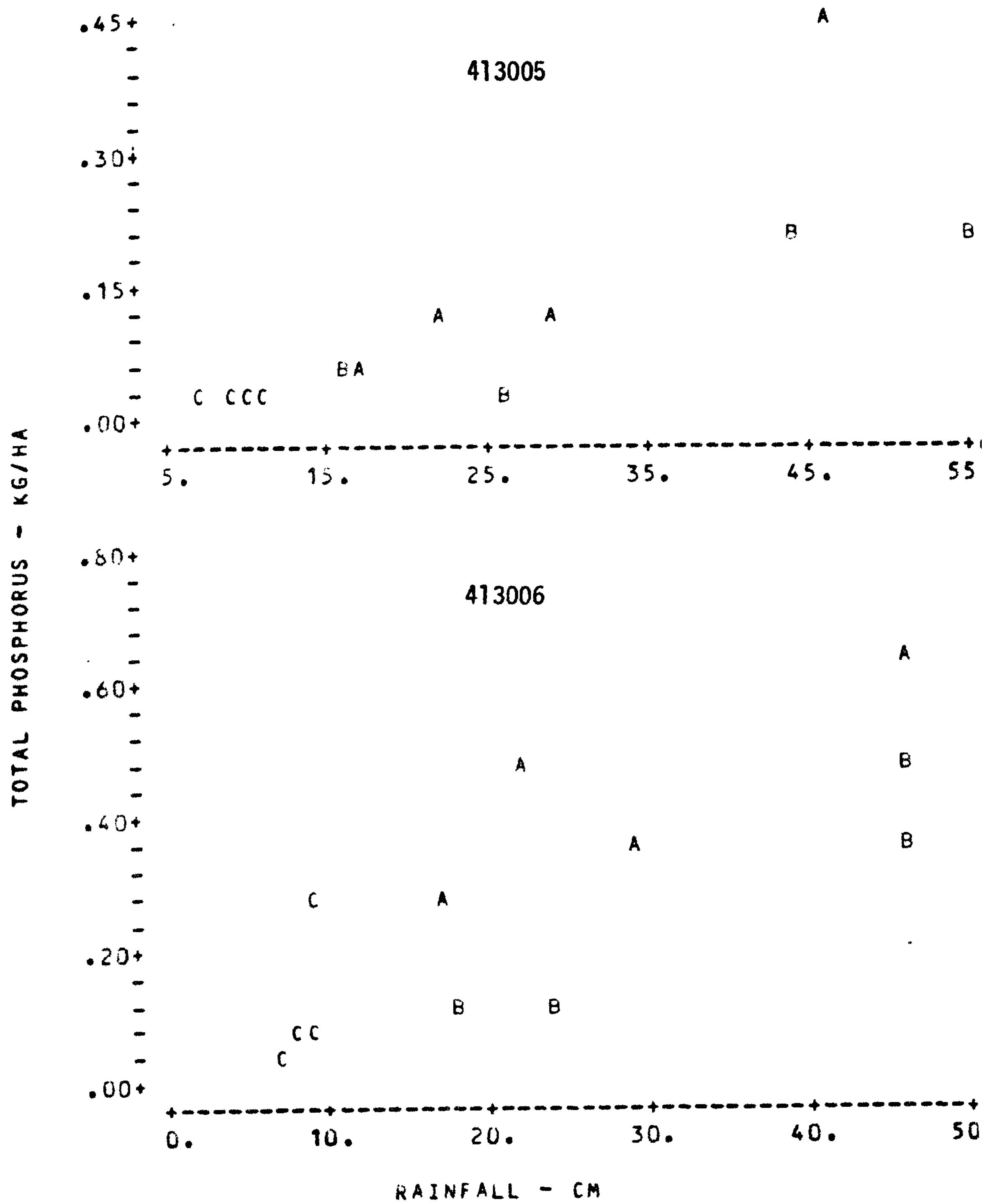

Fig. II-A-39. Relationship of seasonal event unit area total P loadings and rainfall at 70th St. (413005) and Honey Creek (413006). (A = Spring, B = Summer, C = Fall)

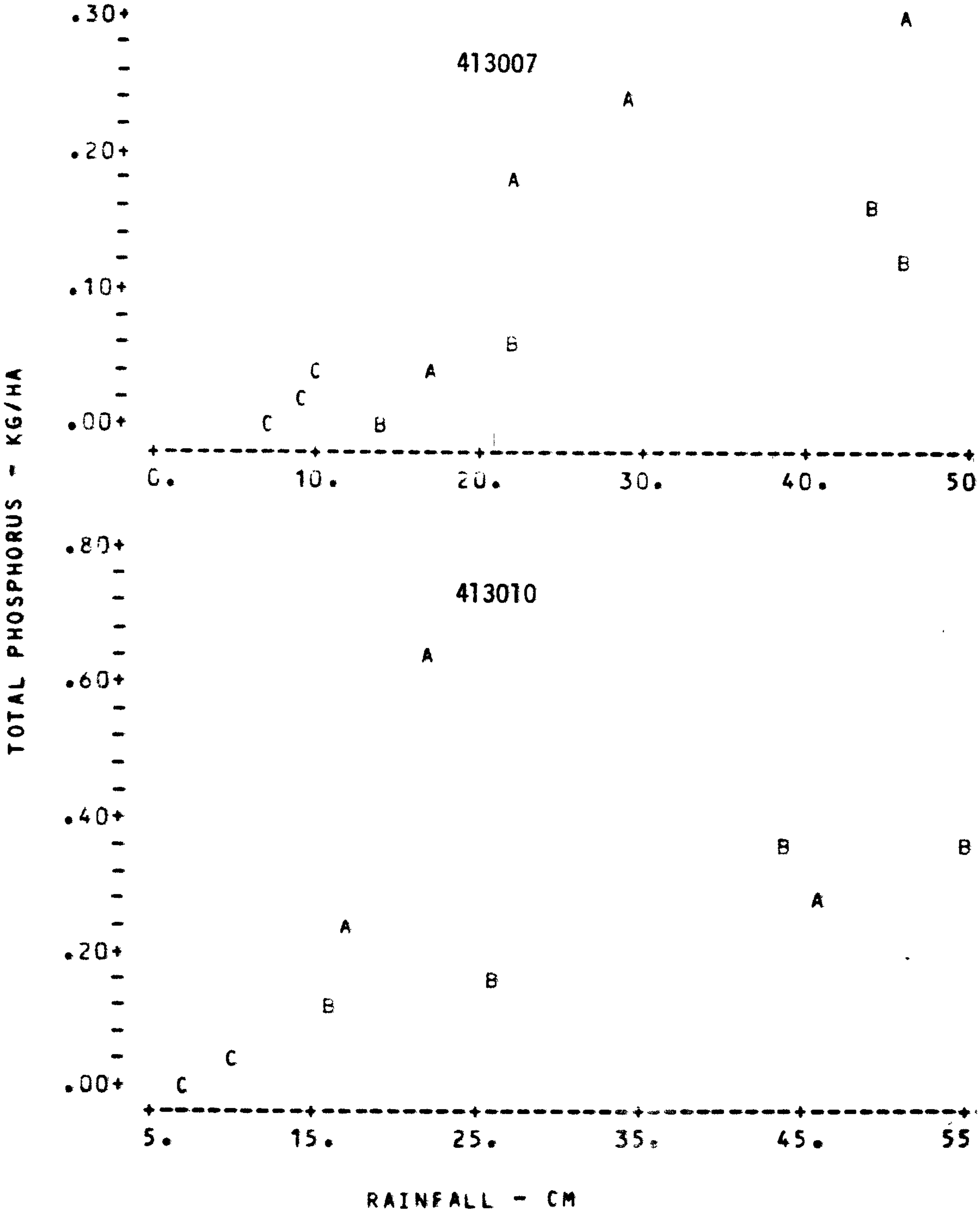

Fig. II-A-40. Relationship of seasonal event unit area total-P loadings and rainfall at Underwoood Creek (413007) and Schoonmaker Creek (413010).
(A = Spring, B = Summer, C = Fall)

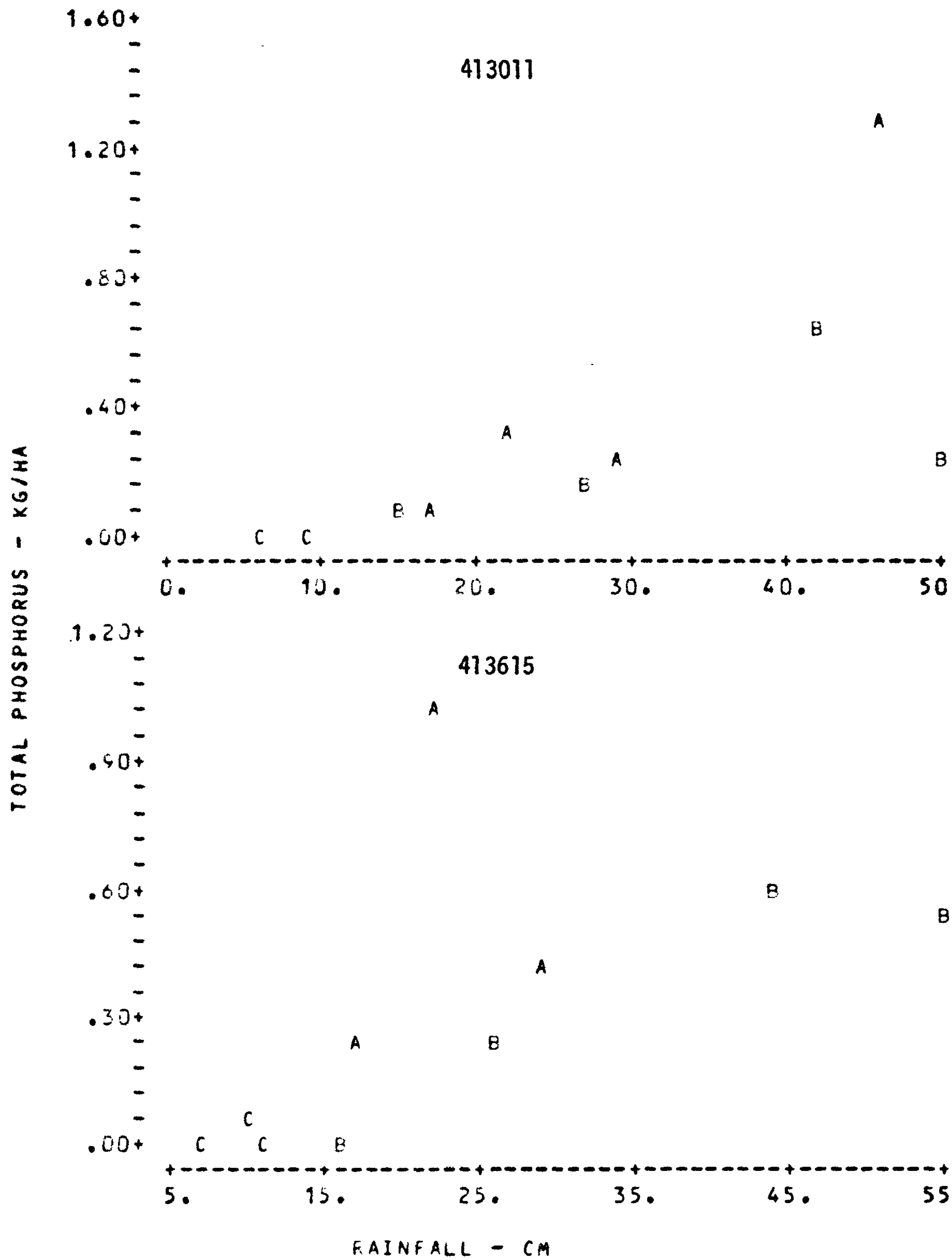

Fig. II-A-41. Relationship of seasonal event unit area total-P loadings and rainfall at Noyes Creek (413001) and Stadium Interchange (413615). (A = Spring, B = Summer, C = Fall)

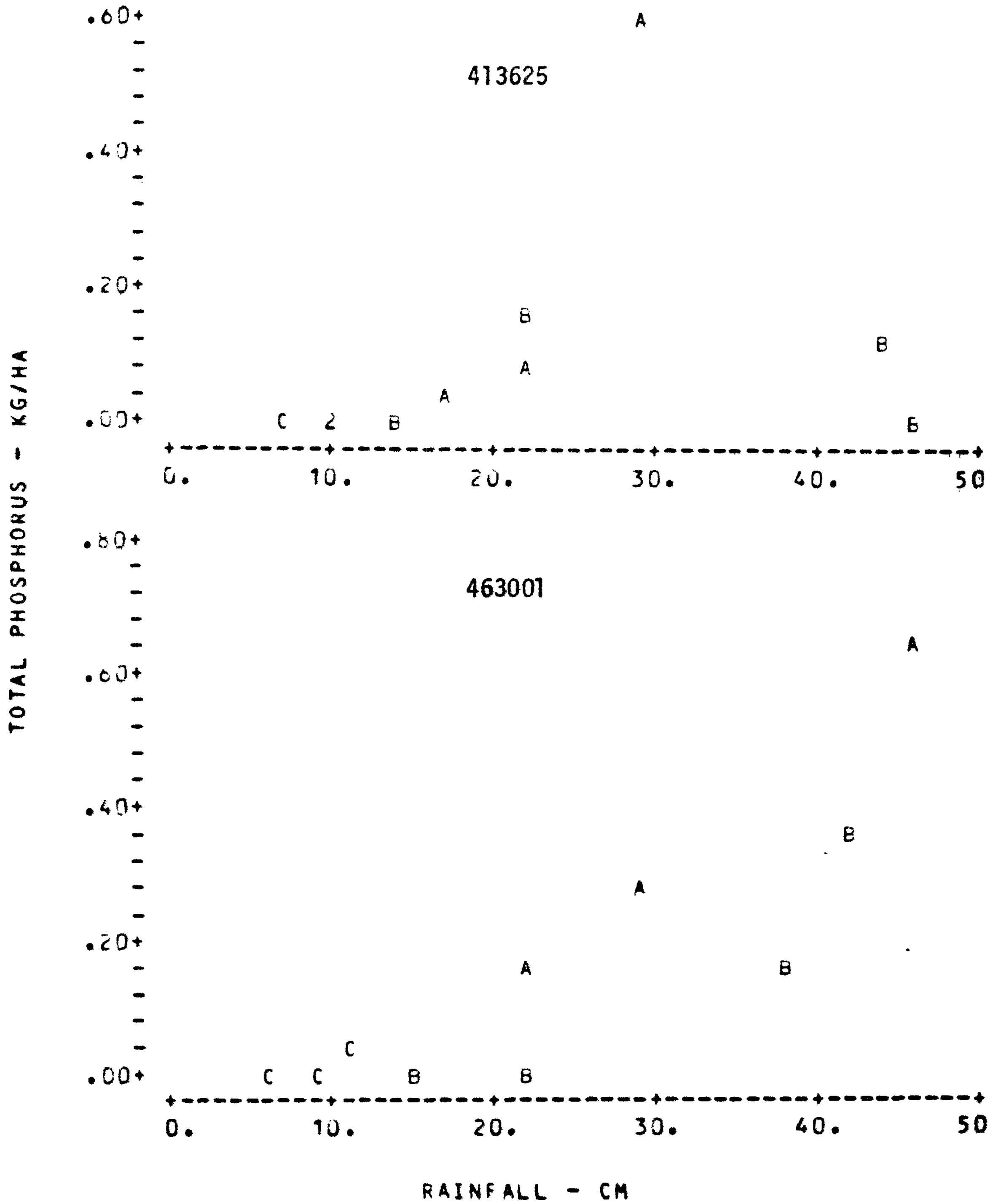

Fig. II-A-42. Relationship of seasonal event unit area total-P loadings and rainfall at New Berlin (413625) and Donges Bay Rd. (463001).
(A = Spring, B = Summer, C = Fall)

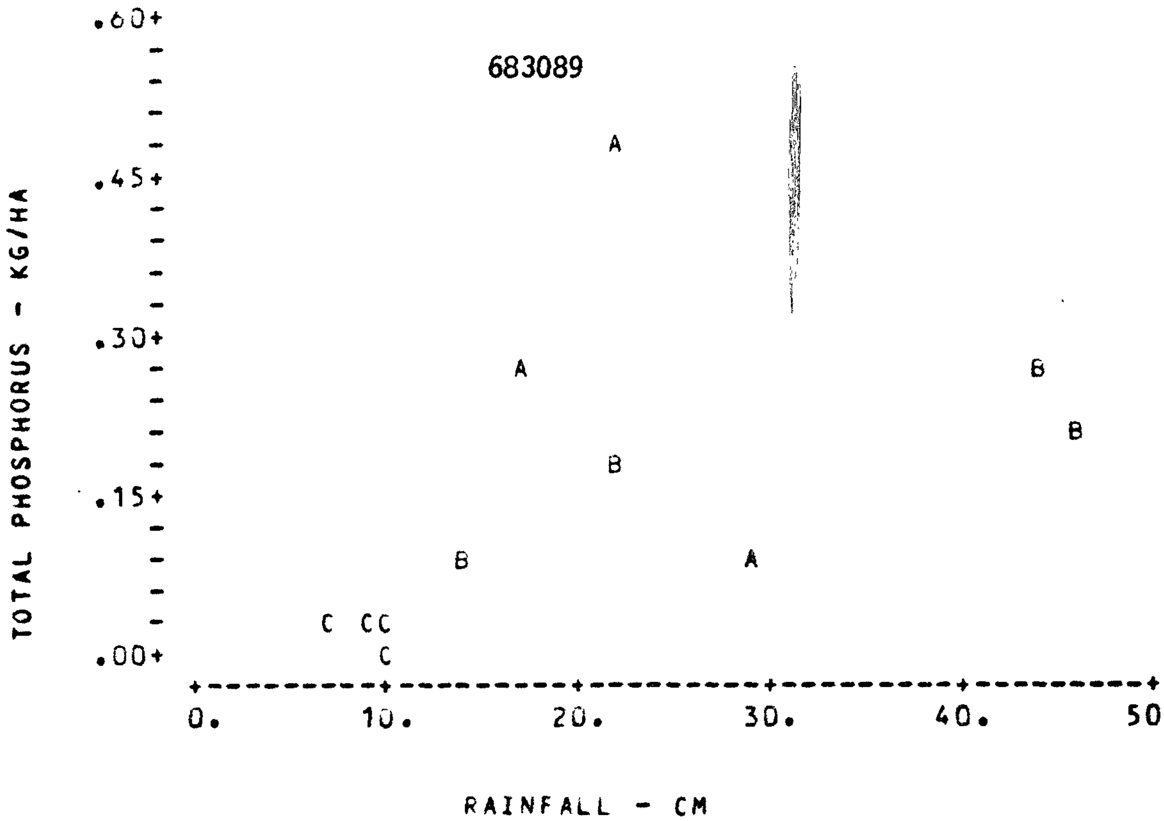

Fig. II-A-43. Relationship of seasonal event unit area total-P loadings and rainfall at Brookfield Square (683089).
(A = Spring, B = Summer, C = Fall)

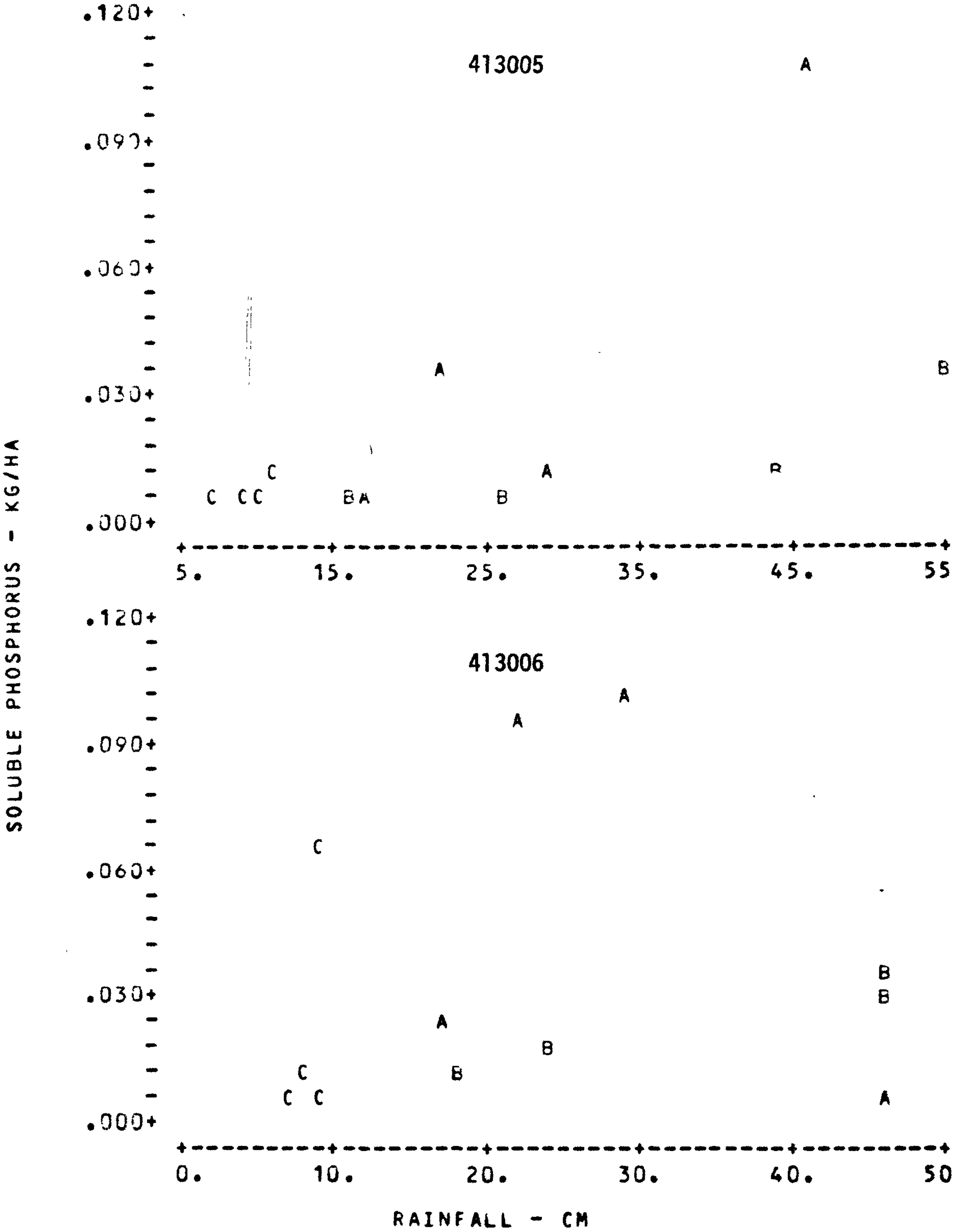

Fig. II-A-44. Relationship of seasonal event unit area soluble-P loadings and rainfall at 70th St. (413005) and Honey Creek (413006). (A = Spring, B = Summer, C = Fall)

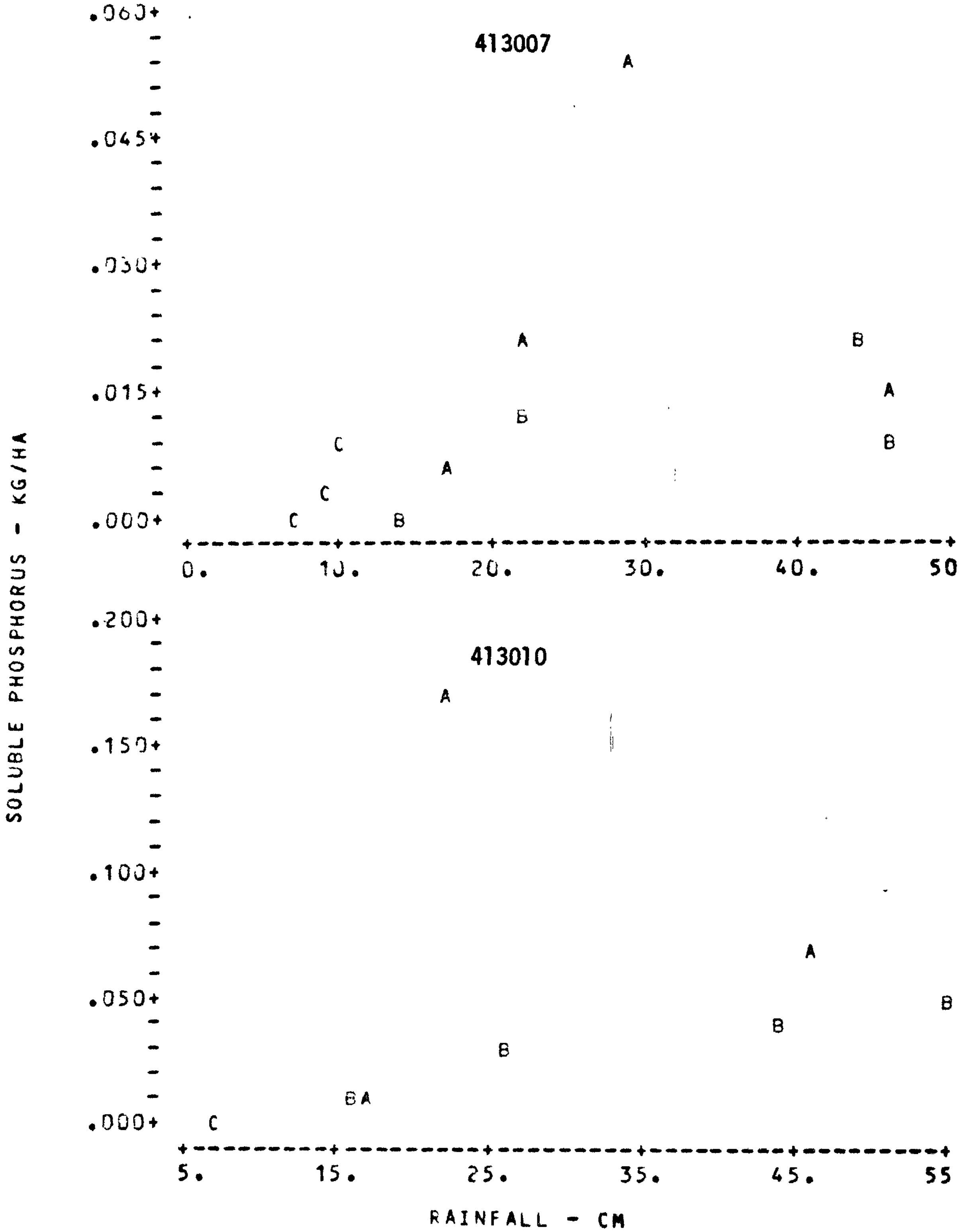

Fig. II-A-45. Relationship of seasonal event unit area soluble-P loadings and rainfall at Underwood Creek (413007) and Schoonmaker Creek (413010).
(A = Spring, B = Summer, C = Fall)

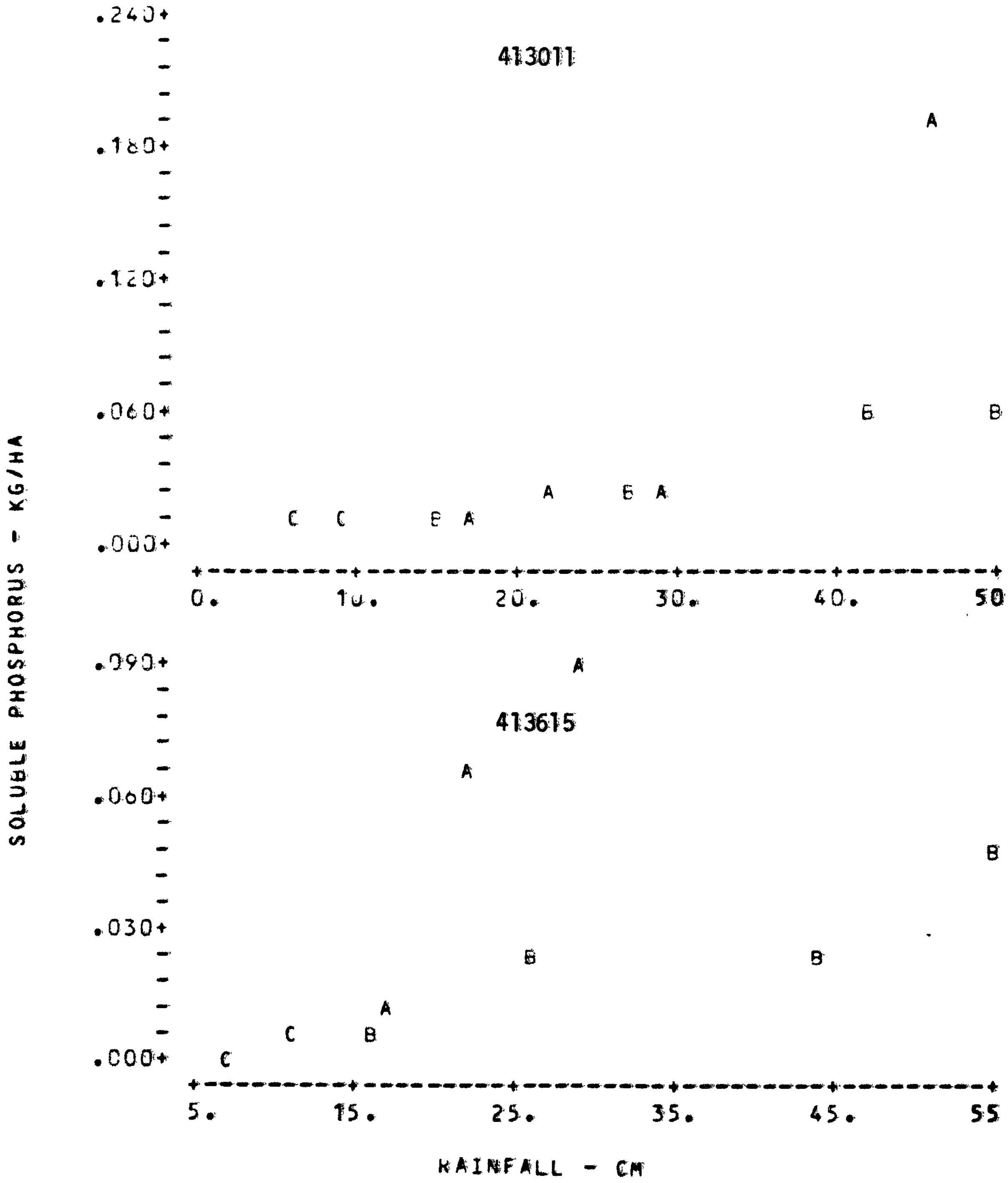

Fig. II-A-46. Relationship of seasonal event unit area soluble-P loadings and rainfall at Noyes Creek (413011) and Stadium Interchange (413615).
(A = Spring, B = Summer, C = Fall)

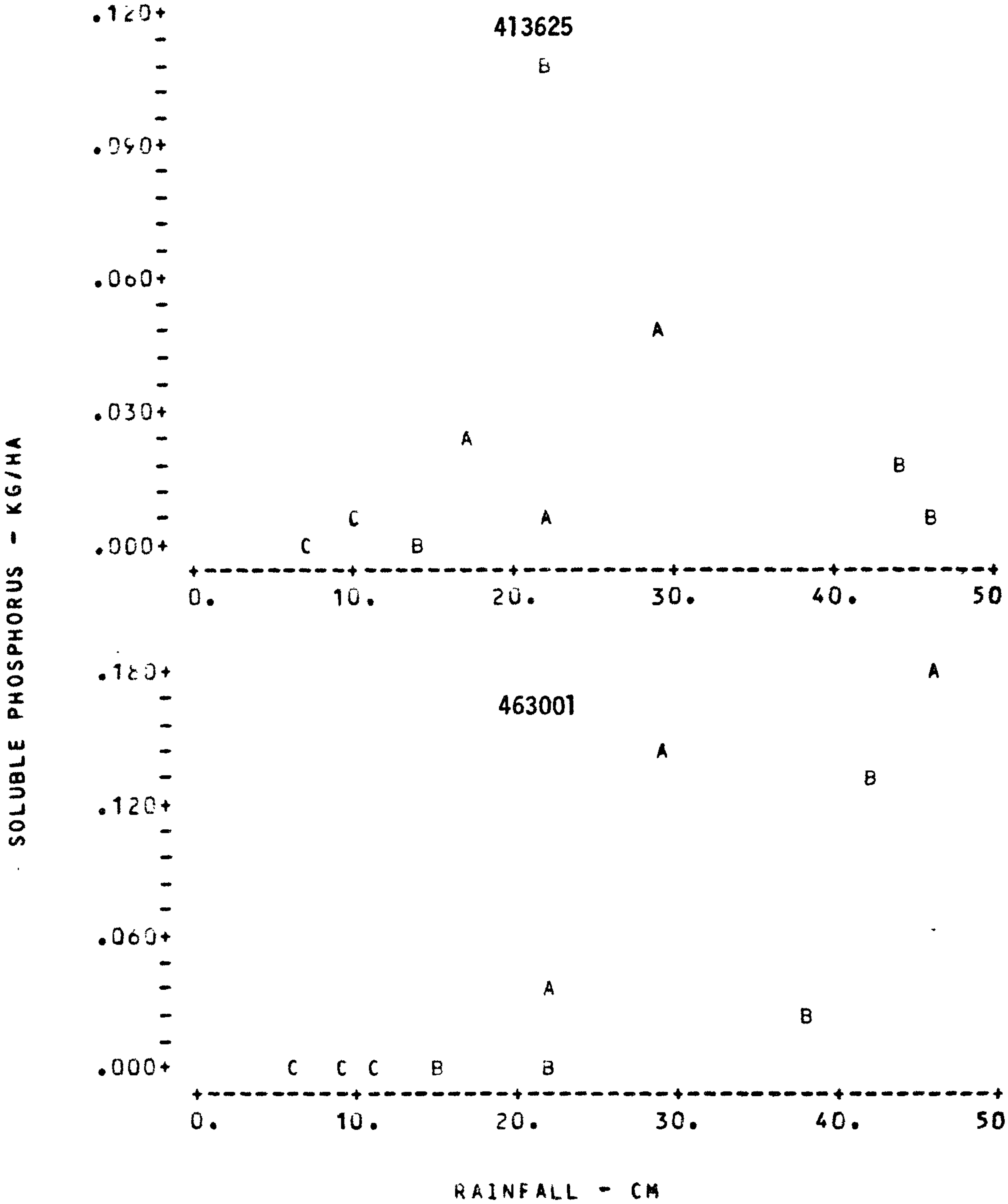

Fig. II-A-47. Relationship of seasonal event unit area soluble-P loadings and rainfall at New Berlin (413625) and Donges Bay Rd. (463001). (A = Spring, B = Summer, C = Fall)

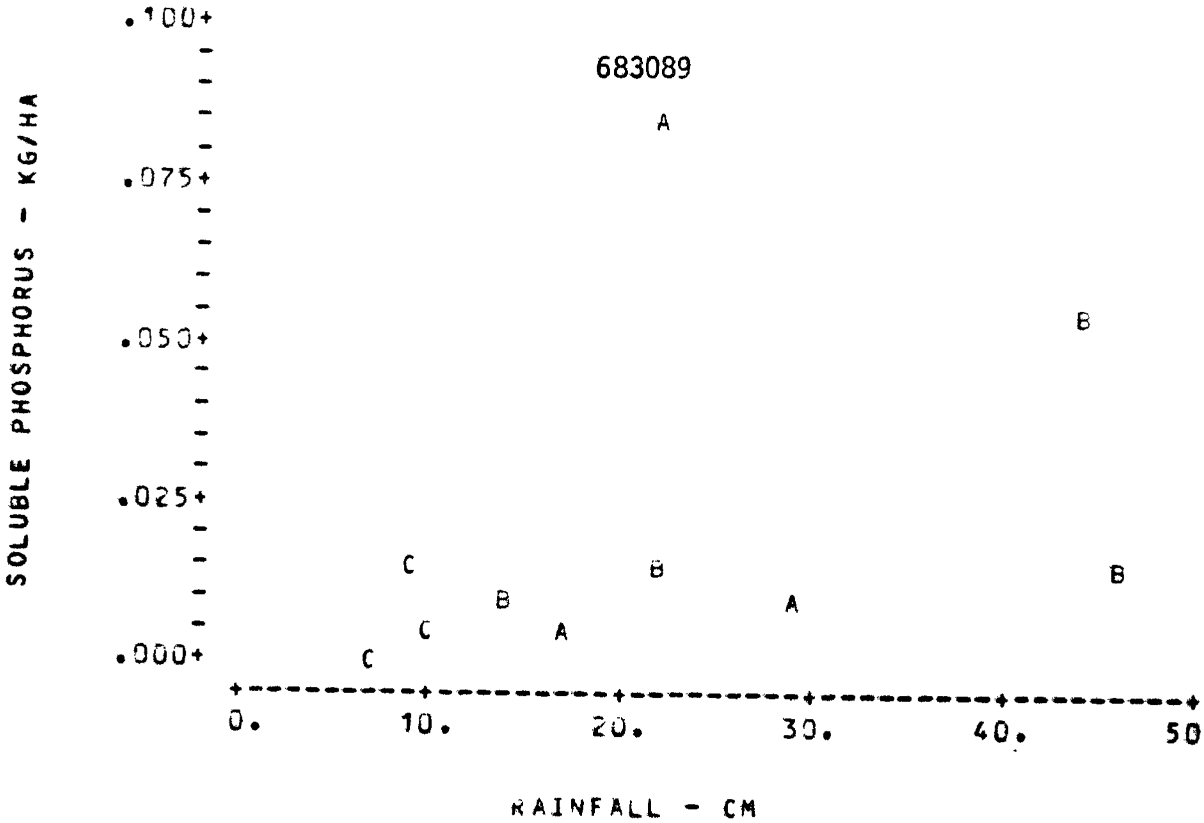

Fig. II-A-48. Relationship of seasonal event unit area soluble-P loadings and rainfall at Brookfield Square (683089). (A = Spring, B = Summer, C = Fall)

Table II-A-10. Snow and frost depth* for 1975 to 1979

Year	Spring Starting Dates**	Frost Records: Days of frozen ground in spring	Frost Records: Depth at start of spring (cm)	Snow Depth at start of spring (cm)
1975	3/15	33	27	13
1976	2/2	25	42	25
1977	3/9	23	14	0
1978	4/3	0	0	0
1979	3/2	0	0	25

* Source "Wisconsin Snow and Frost Depth Report", USDA Statistical Reporting Service.
** Start of spring is defined as beginning of sustained high flows and the end of spring is always May 31.

Table II-A-11. Snowfall and rainfall* on frozen ground for 1975 to 1979

Year	Spring** Starting Dates	Snowfall after start of spring (cm): Snowfall	Snowfall after start of spring (cm): Water Equivalent	Rainfall on Frozen Ground (cm)
1975	3/15	36	4	3.6
1976	2/2	23	7	15.7
1977	3/9	36	4	1.0
1978	4/3	0	0	0
1979	3/2	18	3	0

* NOAA records from General Mitchell Field in Milwaukee.
** Start of spring is defined as beginning of sustained high flows and May 31 was defined as the end of spring.