Contract Report 561

Influence of Wetlands on Streamflow in Illinois

by Misganaw Demissie and Abdul Khan
Office of Sediment & Wetland Studies

Prepared for the
Illinois Department of Conservation

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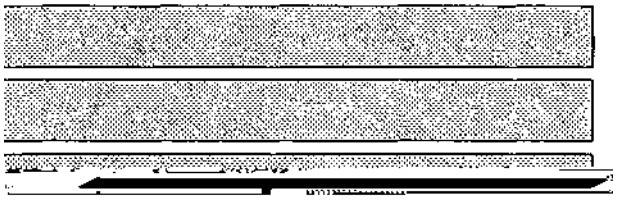

Illinois State Water Survey
Hydrology Division
Champaign, Illinois

A Division of the Illinois Department of Energy and Natural Resources

INFLUENCE OF WETLANDS ON STREAMFLOW IN ILLINOIS

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CONTENTS

	Page
Acknowledgments	ii
Tables	iii
	iv
	vi
	1
re	3
hodology and Study Site Selection	5
Watersheds and Gaging Stations	5
Procedures	5
thesis	5
xflow and Floodflow Volume	5
Flow	10
n Procedure	16
od	17
	20
dflow Volume	20
alysis	20
lysis	20
lysis...	27
-Regional	27
	35
ter	35
ng	35
mmer	36
	36
alysis	36
lysis	40
lysis	40
-Regional	40
	40
ter	40
ng	43
mmer	43
ons	44
	46

FIGURES (concluded)

ABSTRACT

One of the major functions of wetlands is to store water for gradual release to surface and ground-water bodies. It is generally assumed that wetlands reduce flooding, increase low flows, and serve as recharge areas for ground water. However, there have not been systematic studies to quantify the influence of wetlands on flooding and low flows. This research was initiated to investigate the hydrologic functions of wetlands in Illinois based on available streamflow records. The research was designed to answer the more general question, "how does the presence or absence of variable size wetlands in a watershed influence streamflow?"

Streamflow records from 30 gaging stations monitoring watersheds with variable wetland areas were analyzed to assess the influence of wetlands on streamflow. The main objective of the analysis was to determine if streamflow parameters of streams draining watersheds with varying percentage of wetland areas were related to the percentage of wetlands in the watersheds. The streamflow parameters analyzed included peakflow, floodflow volume, and low flow. From the results of this analysis, in general, it can be concluded that peakflow and floodflow volume decrease, and low flows increase with increasing percentage of wetlands in the watershed. The influence of wetlands was more noticeable on peakflow and low flow than on floodflow volume. F Tc 84329cgae c8 395.28l

stream adjoining a wetland than for a stream not adjoining a wetland. As a result, a significant difference will exist between the flow characteristics of a stream adjacent to a wetland and one not adjoining a wetland.

Another major influence that wetlands exert on streamflow is the flood storage capacity they provide. Since most wetlands are located in depressions and poorly drained areas, they provide significant storage potential. By storing runoff from adjoining areas, wetlands retard or reduce the amount of runoff that reaches stream channels. Therefore depending on initial conditions, wetland areas could significantly affect the streamflow.

The presence of wetlands in a watershed may also result in low-flow augmentation in streams. In wetland areas, water stored in surficial depressions and underground is gradually released to adjoining streams during periods of low flows. This generally results in higher low-flow conditions for streams that drain areas containing wetlands.

One of the parameters that can be used to characterize and distinguish watersheds containing different areas of wetlands is the ratio of wetland area to the total drainage area of the watershed. The major objective of this study, therefore, was to investigate streamflow records in Illinois and then relate various streamflow parameters to the percentage of wetlands in the watershed. Although it is generally accepted that wetlands reduce streamflow peaks and increase low flows, this generalized concept may not always be true. The hydrologic response of wetlands may vary depending on geographic location, storm intensity and duration, and season of the year. Because of significant regional and seasonal differences in Illinois, it is important to ascertain if the influence of wetlands varies between regions and by season. This research effort has attempted to address issues related to the regional and seasonal influence of wetlands on streamflow in Illinois. However, because of the small number of gaging stations in the different regions, the regional analysis needs to include more stations in the analysis.

Table 1. Information on Streamflow Gaging Stations Used in the Study

Streamflow station	*ID number*	*Stream name*	*Drainage area (sqmi)*	*Wetland (percent)*	*Period of record*
03336645	1	Middle Fork Vermilion	428.00	1.34	1979-1988
03336900	2	Salt Fork River	131.10	0.22	1960-1988
03379500	3	Little Wabash	1118.90	1.06	1915-1988
03380500	4	Skillet Fork	457.83	4.04	1929-1988
03382100	5	South Fork Saline	145.10	9.29	1966-1988
03384450	6	Lusk Creek	42.40	0.47	1969-1988
05466500	7	Edwards River	440.30	1.08	1935-1988
05469000	8	Henderson Creek	430.30	0.82	1935-1988
05495500	9	Bear Creek	345.20	1.87	1944-1988
05532000	10	Addison Creek	22.90	0.76	1952-1988
05534500	11	North Branch Chicago	19.50	4.41	1953-1988
05536000	12	North Branch Chicago	98.10	3.52	1951-1988
05536275	13	Thorn Creek	102.90	8.64	1947-1988
05539900	14	West Branch DuPage	27.90	6.06	1961-1988
05540095	15	West Branch DuPage	92.30	7.53	1969-1988
05550500	16	Poplar Creek	35.50	7.28	1952-1988
05551700	17	Blackberry Creek	69.60	4.19	1961-1988
05568800	18	Indian Creek	62.20	0.47	1960-1988
05570370	19	Big Creek	40.70	8.43	1972-1988
05570380	20	Slug Run	7.10	13.68	1975-1988
05570910	21	Sangamon	237.70	0.80	1979-1988
05585000	22	La Moine	1281.80	2.27	1921-1988
05591200	23	Kaskaskia	468.90	0.87	1971-1988
05593520	24	Crooked Creek	251.60	5.80	1975-1988
05594450	25	Silver Creek	152.49	4.17	1967-1988
05594800	26	Silver Creek	460.75	5.64	1971-1988
05595200	27	Richland Creek	127.12	2.65	1970-1988
05595730	28	Rayse Creek	90.40	4.23	1979-1988
05597000	29	Big Muddy River	783.60	11.78	1915-1988
05597500	30	Crab Orchard	31.30	8.09	1952-1988

Figure 1. Locations of selected drainage basins, streamgaging stations, and precipitation stations

Figure 2. Frequency distribution of drainage areas of selected watersheds

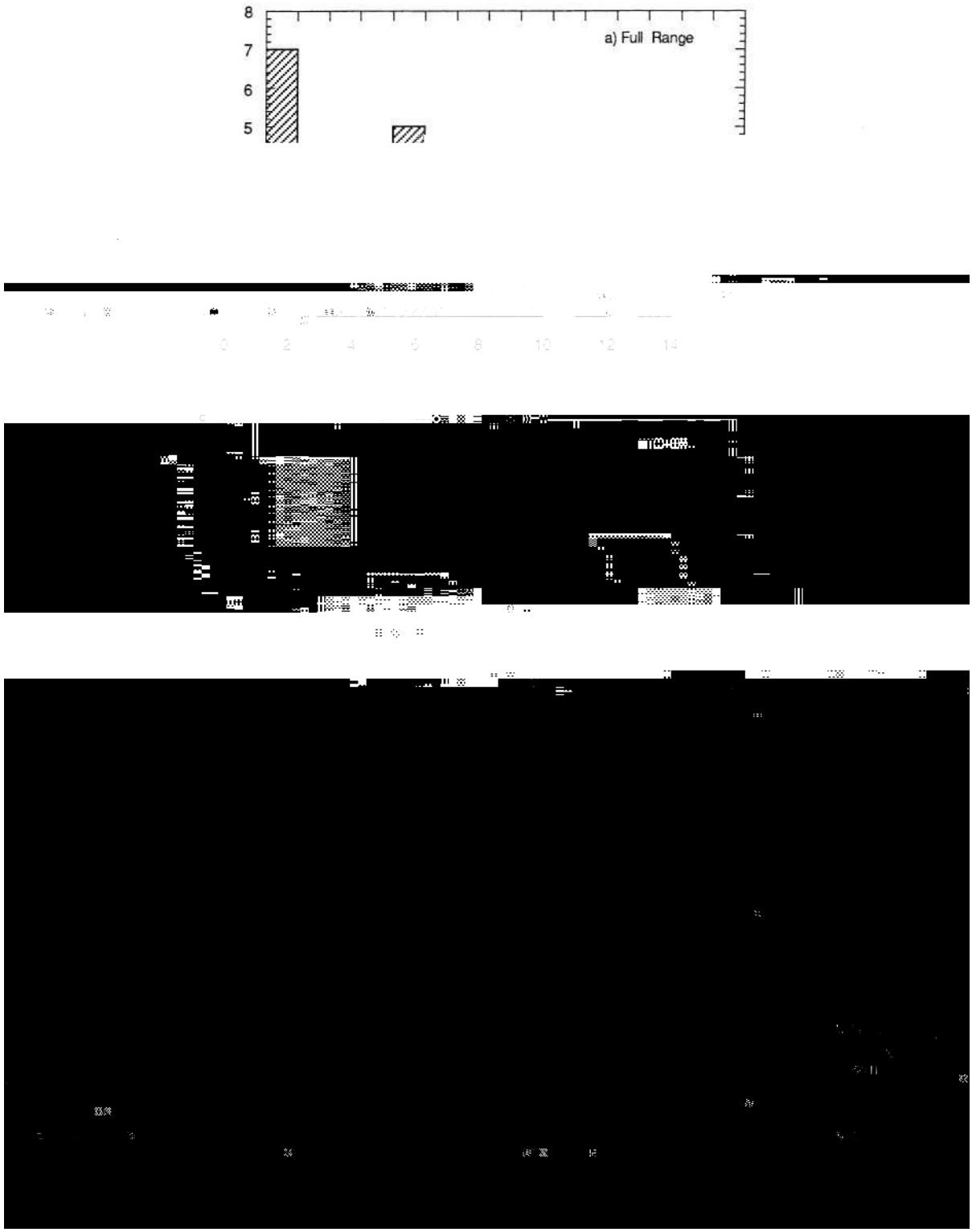

Figure 3. Frequency distribution of wetland percentages in selected watersheds

in precipitation from the analysis, four ratios were then calculated for each flood event to aid in the analysis: peakflow to average precipitation ratio; peakflow to peak precipitation ratio; peakflow to total precipitation ratio; and floodflow volume to total precipitation ratio.

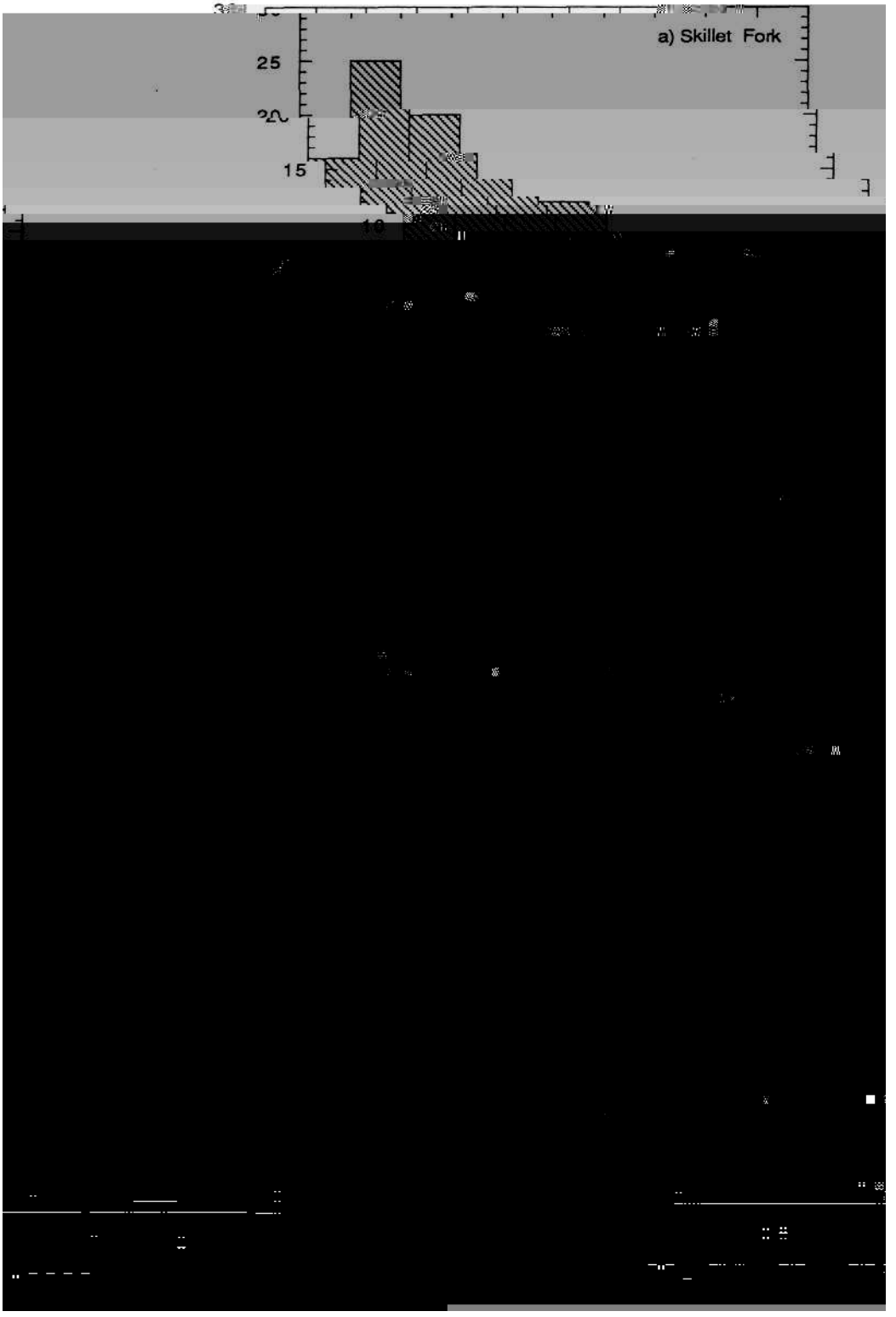

Figure 4. Frequency distribution of storm values of peakflow to average precipitation ratio for three selected stations

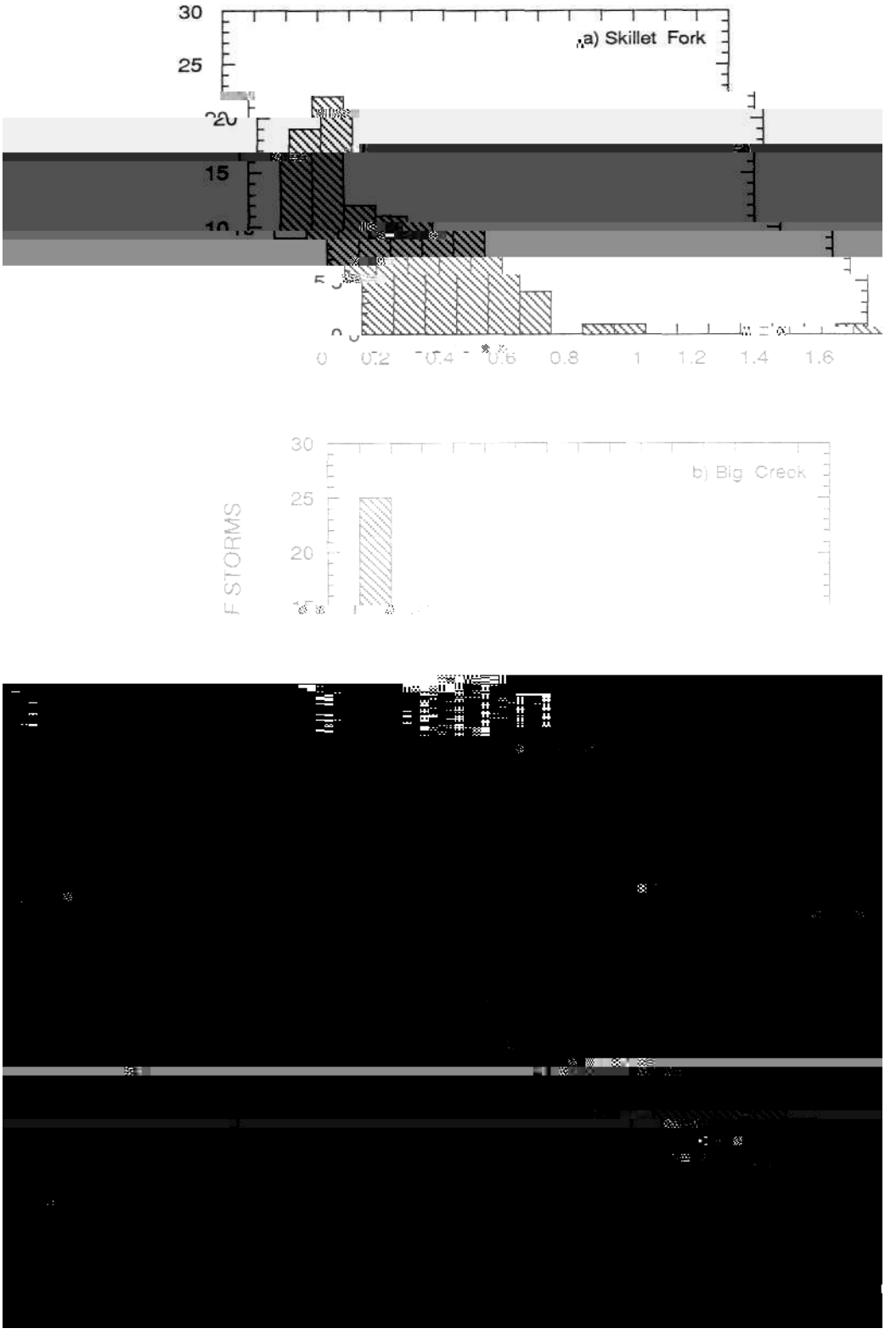

Figure 5. Frequency distribution of storm values of peakflow to peak precipitation ratio for three selected stations

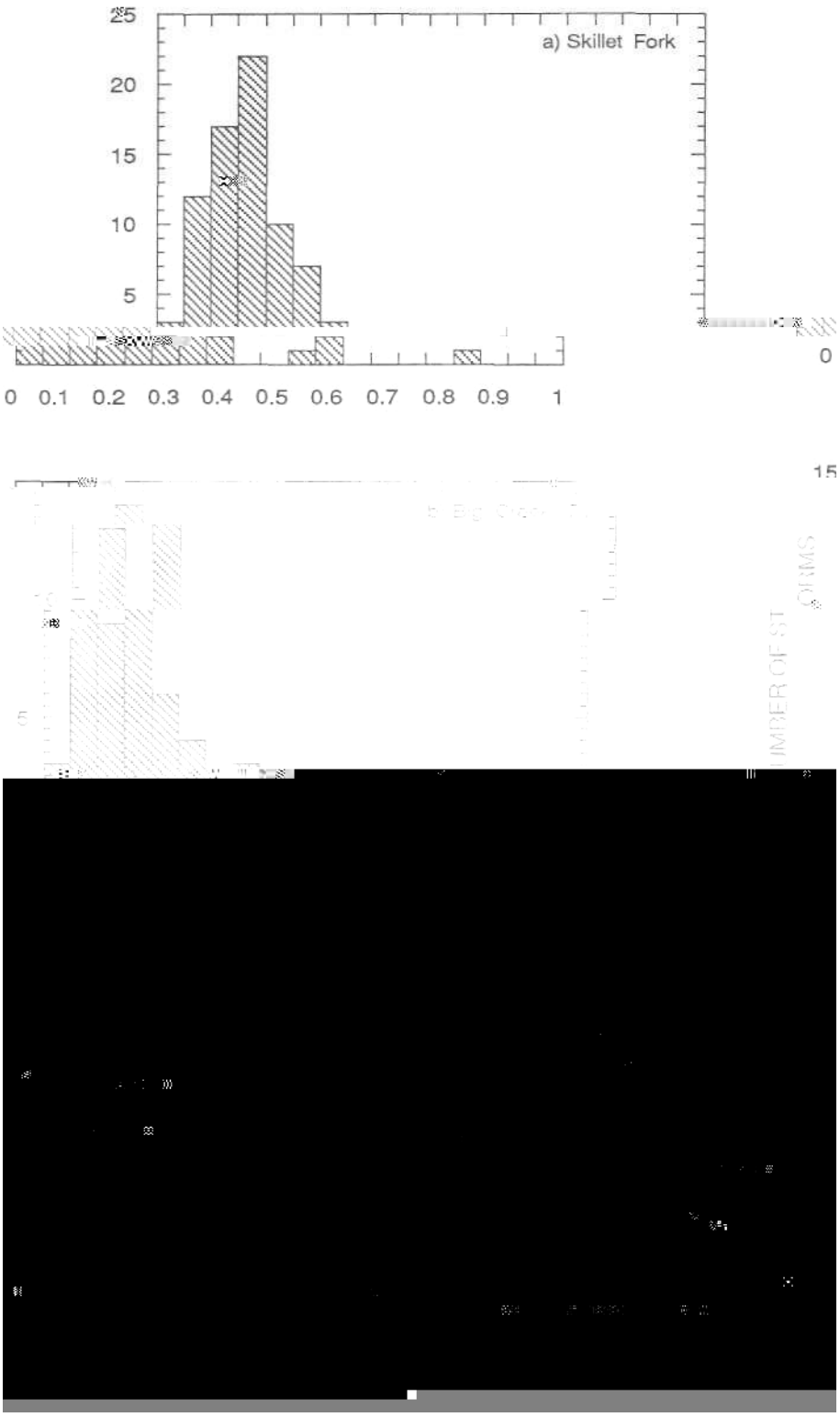

Figure 6. Frequency distribution of storm values of peakfloqm0 Tc(n)>pBfe.1f91w-0.19T

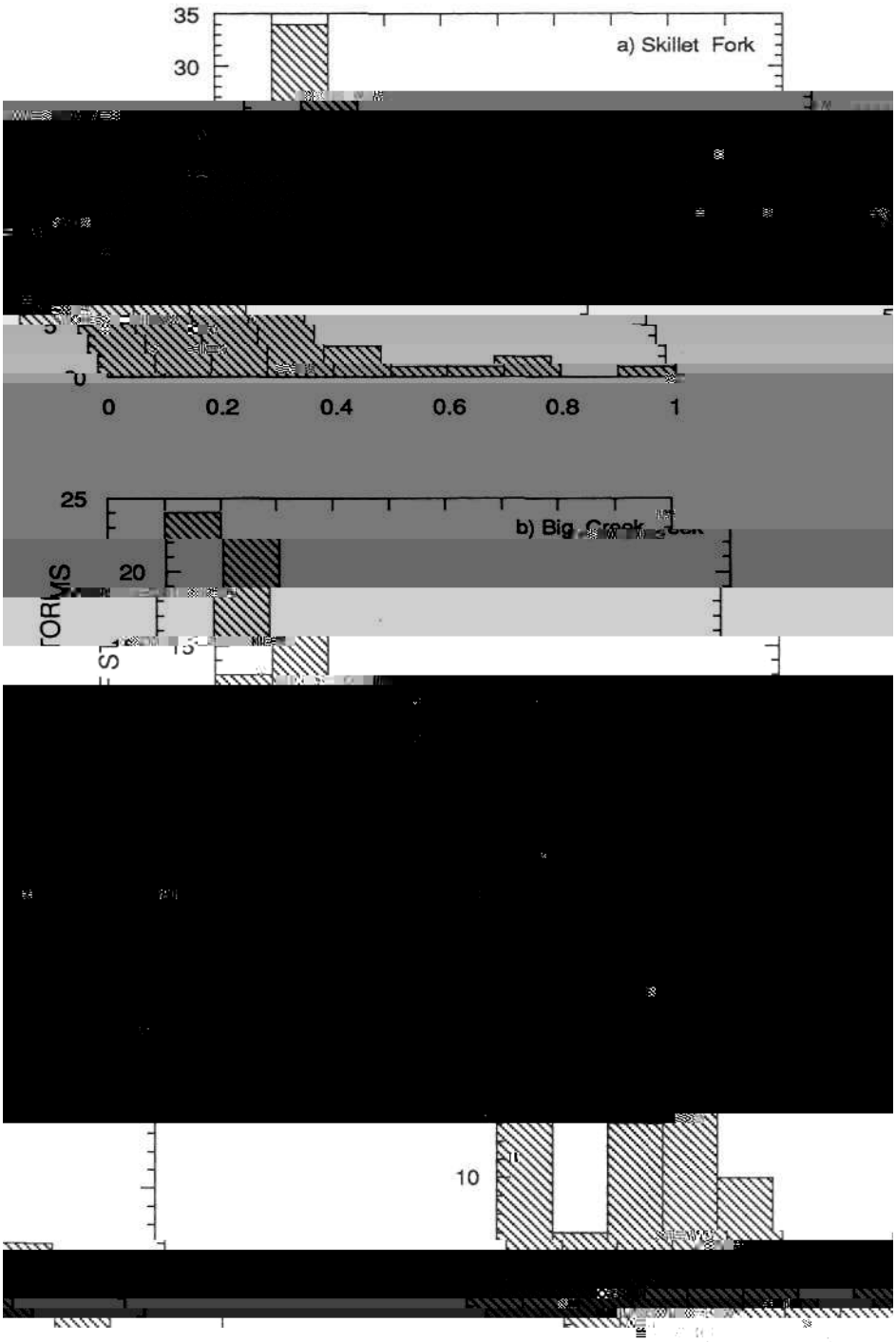

Figure 7. Frequency distribution of storm values of floodflow volume to total precipitation ratio for three selected stations

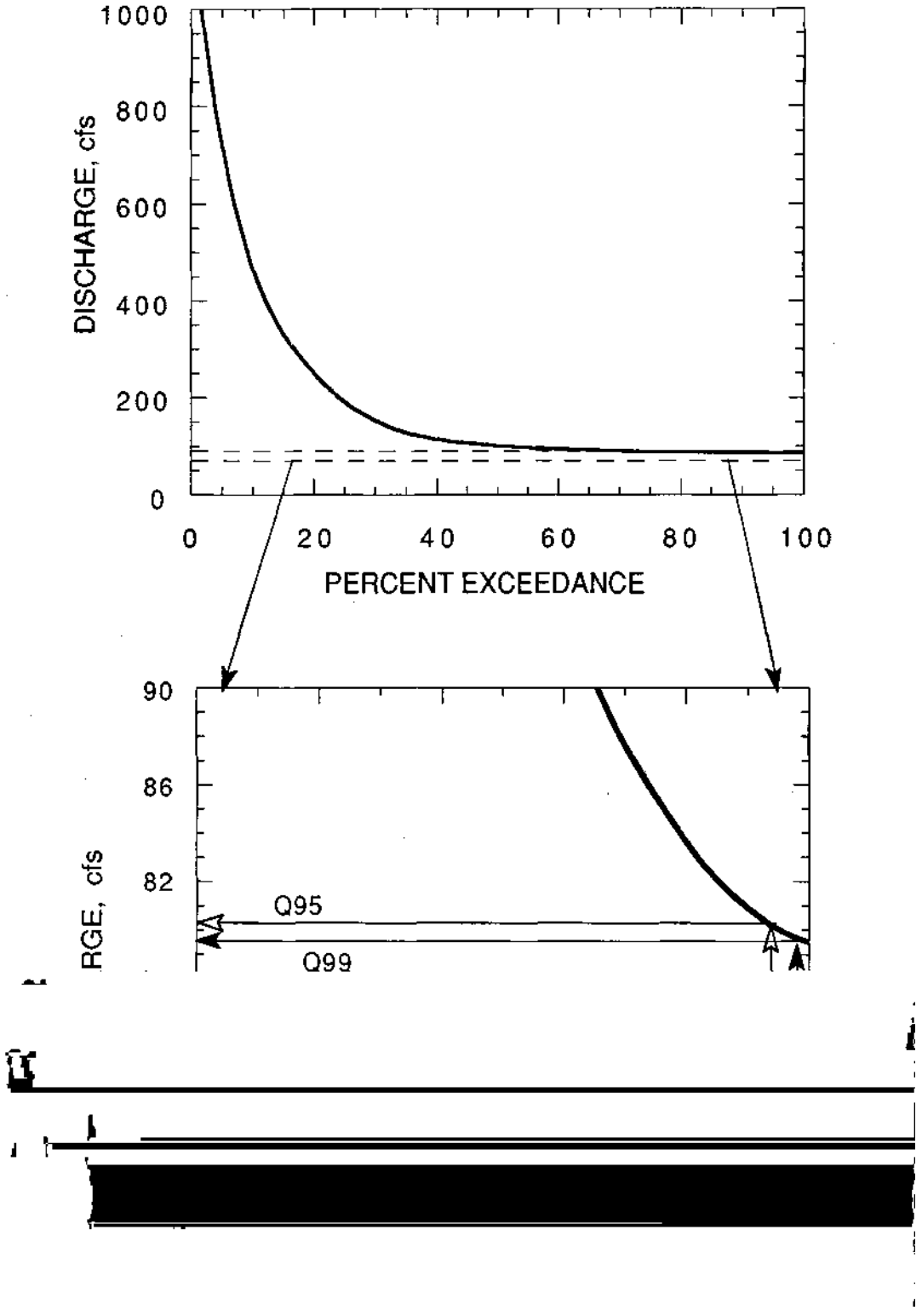

Figure 8. Determination of flows at different exceedance probabilities

Evaluation Procedure

For each flow parameter, the influence of wetlands on streamflow was studied using the linear regression analysis method. Regression analysis is a procedure for fitting an equation to a set of data. For a given set of measurements on two or more variables, regression analysis

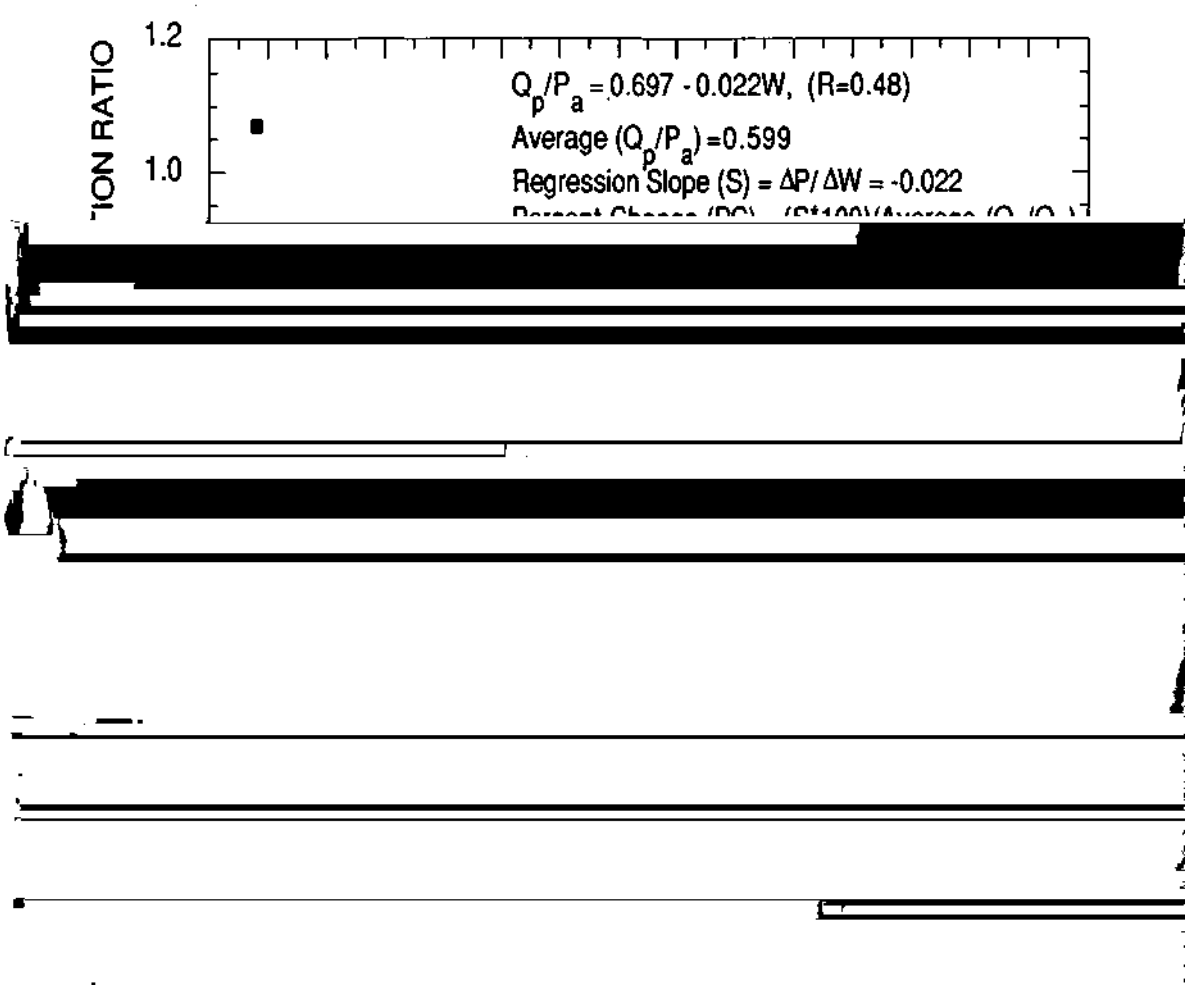

Figure 9. Percent change (PC) determination from regression parameters

where *PC* is the calculated percentage change for an increase of one percent wetland area in the watershed and PC_t is the threshold percentage change. The symbol | | implies absolute value. A positive (+) sign of the computed *PC* represents an increase in the parameter value and a negative (-) sign of the computed *PC* represents a decrease in the parameter value with increasing wetland percentage in the watershed.

RESULTS

The results of this study relating changes in peakflow, floodflow volume, and low flow to percent wetland change are presented in this section. The results are based on the

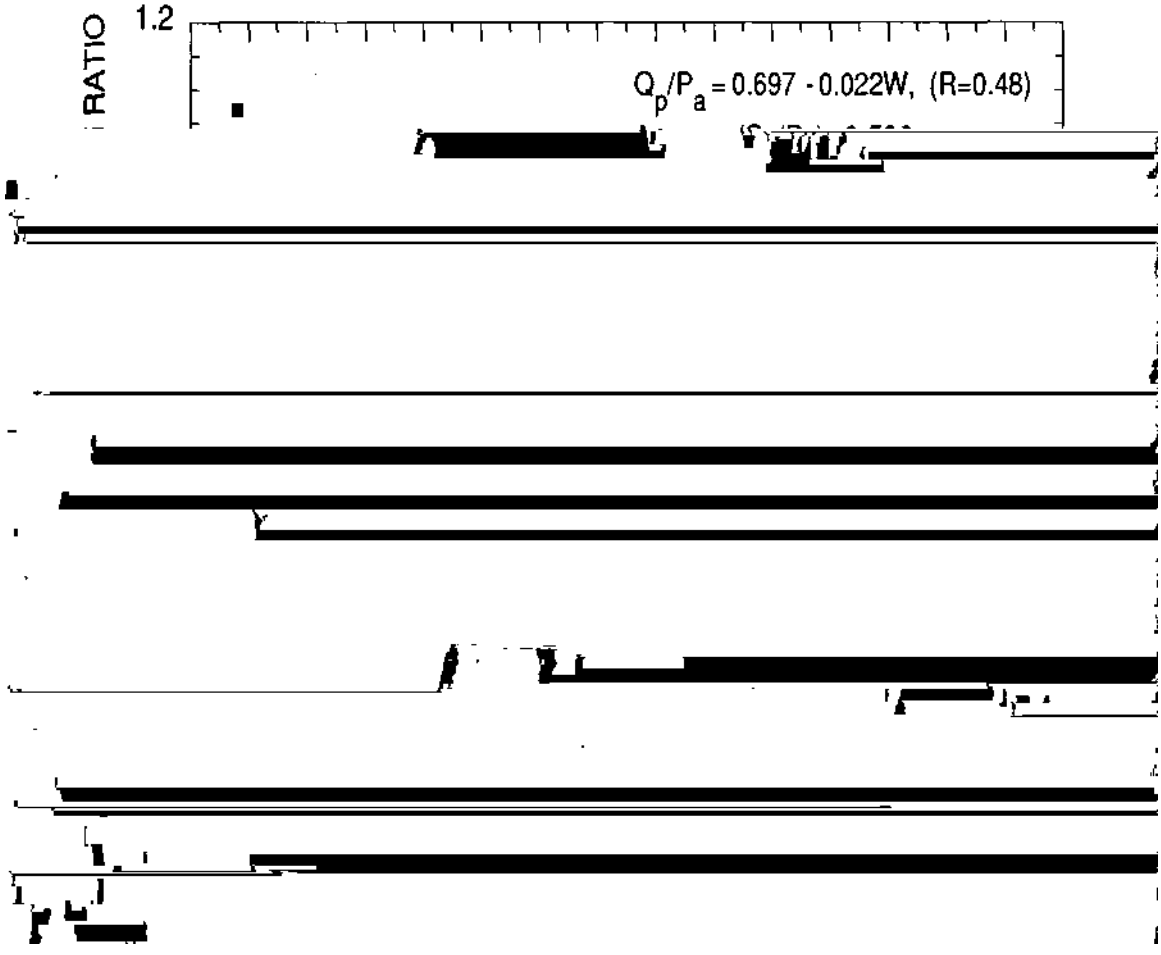

Figure 10. Relation between peakflow to average precipitation ratio and percent wetland for Illinois

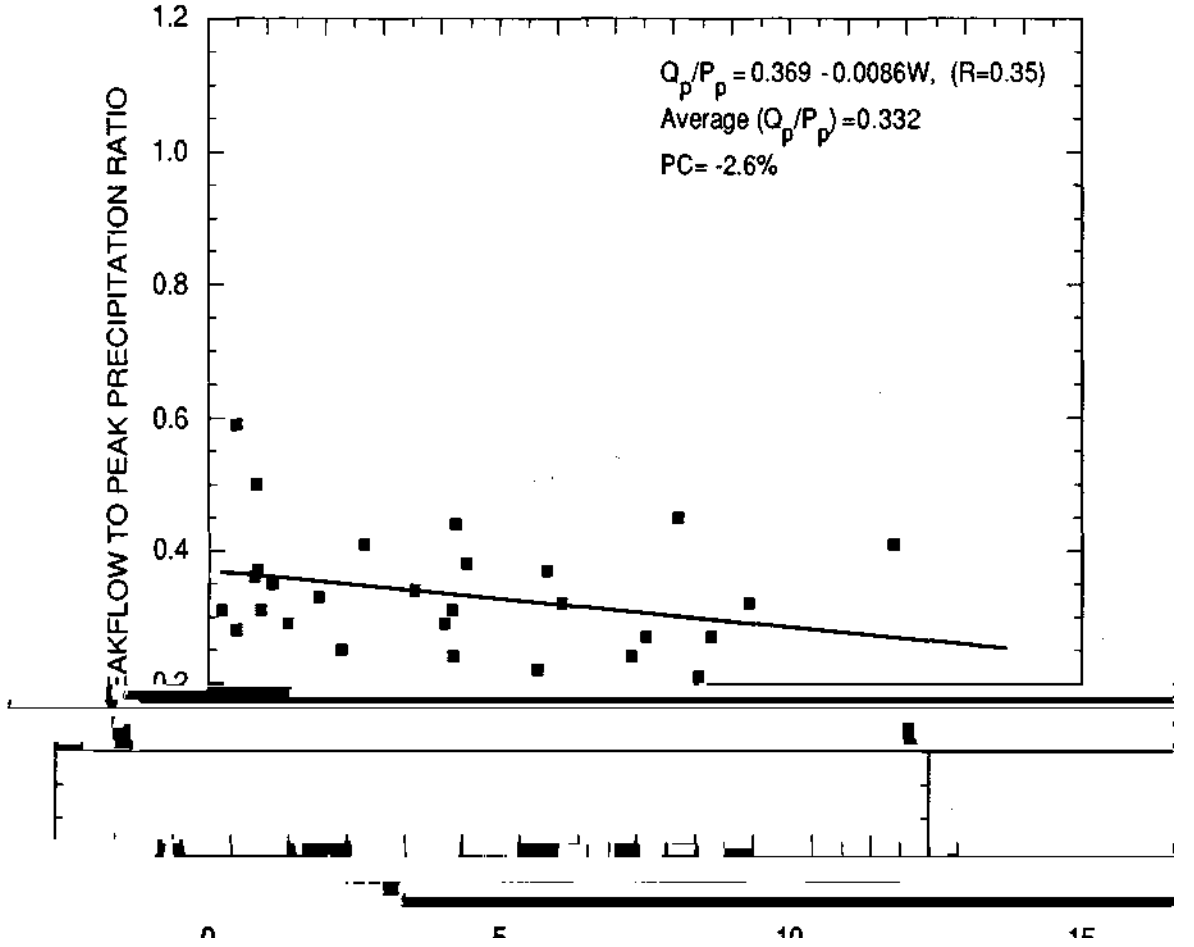

Figure 11. Relation between peakflow to peak precipitation ratio and percent wetland for Illinois

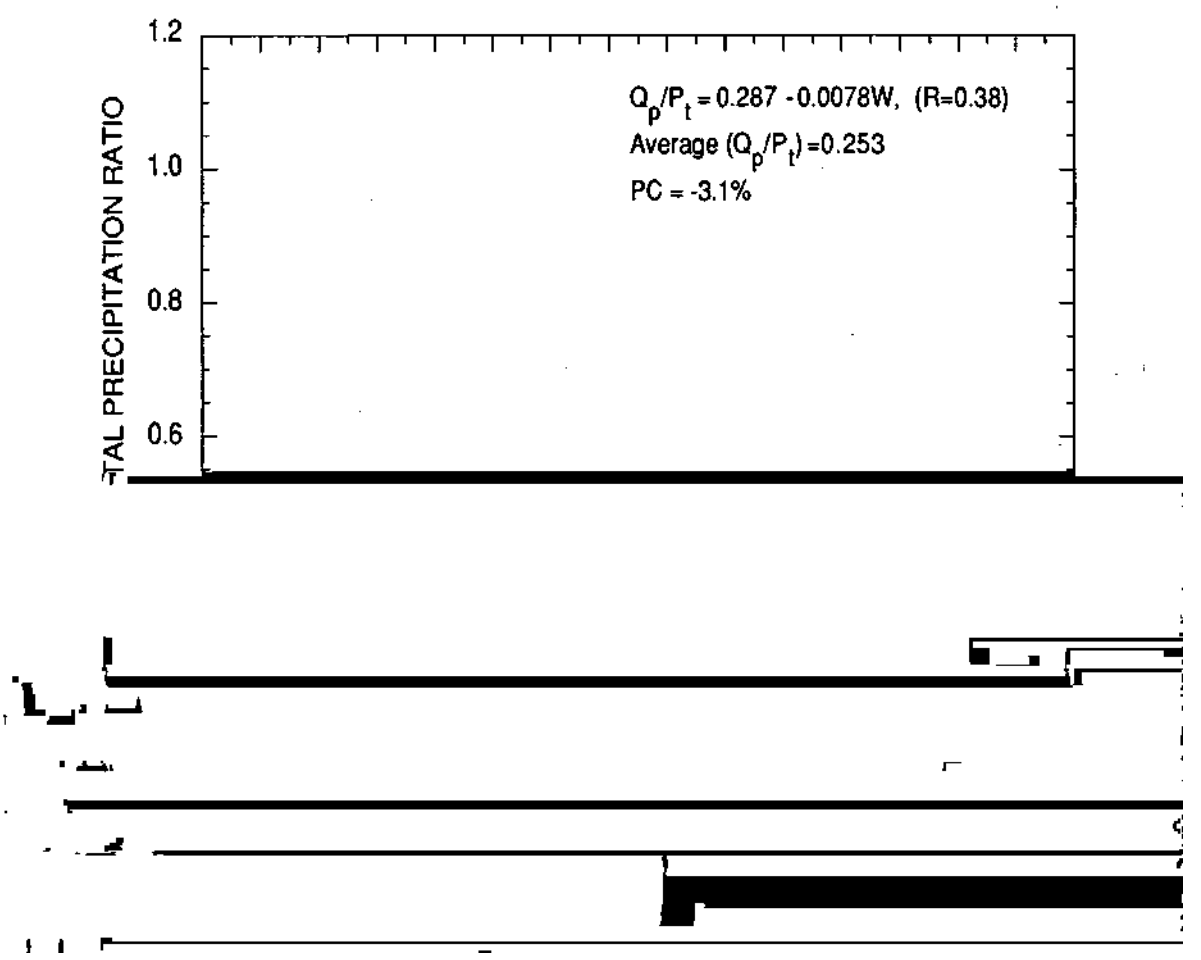

Figure 12. Relation between peakflow to total precipitation ratio and percent wetland for Illinois

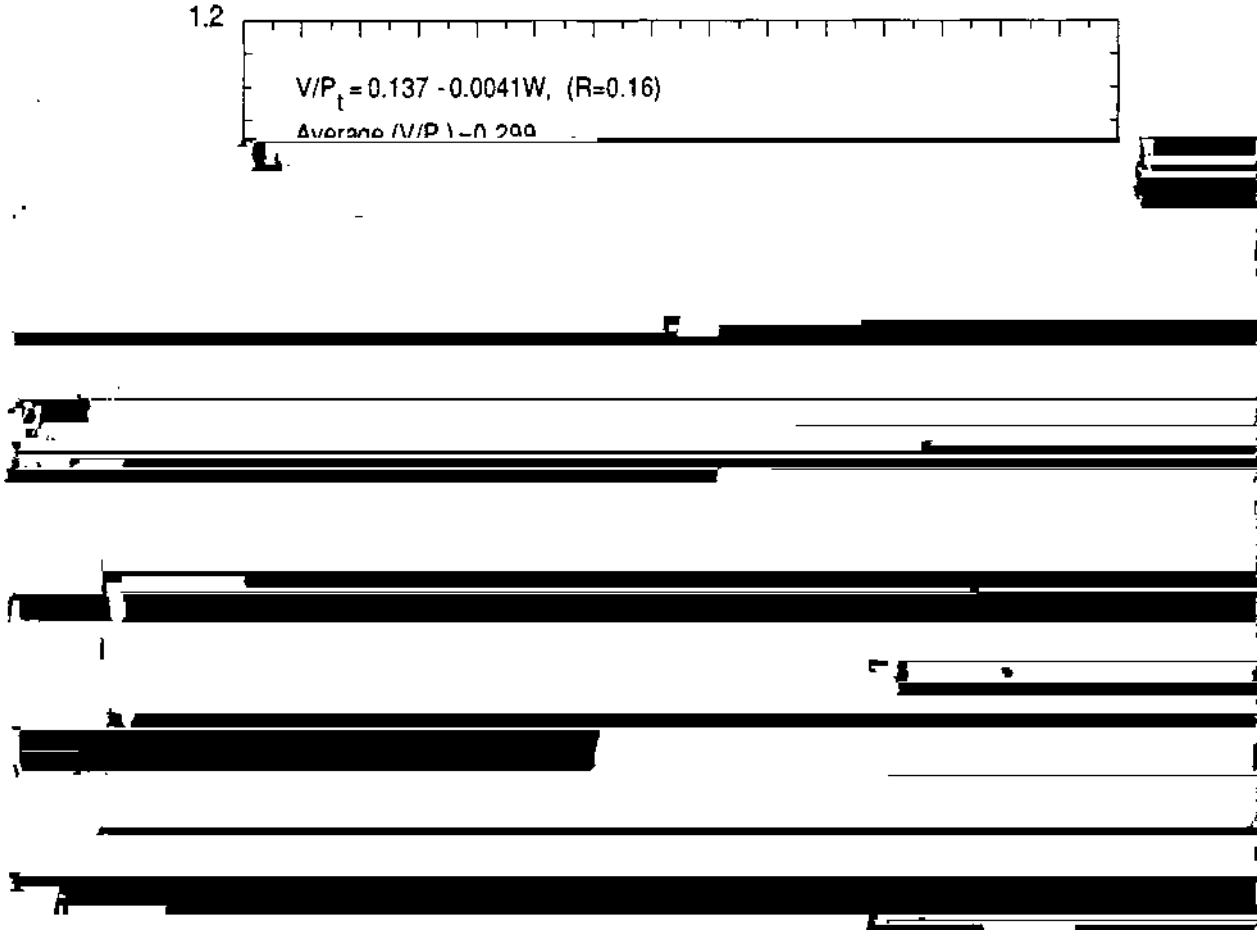

Figure 13. Relation between floodflow volume to total precipitation ratio and percent wetland for Illinois

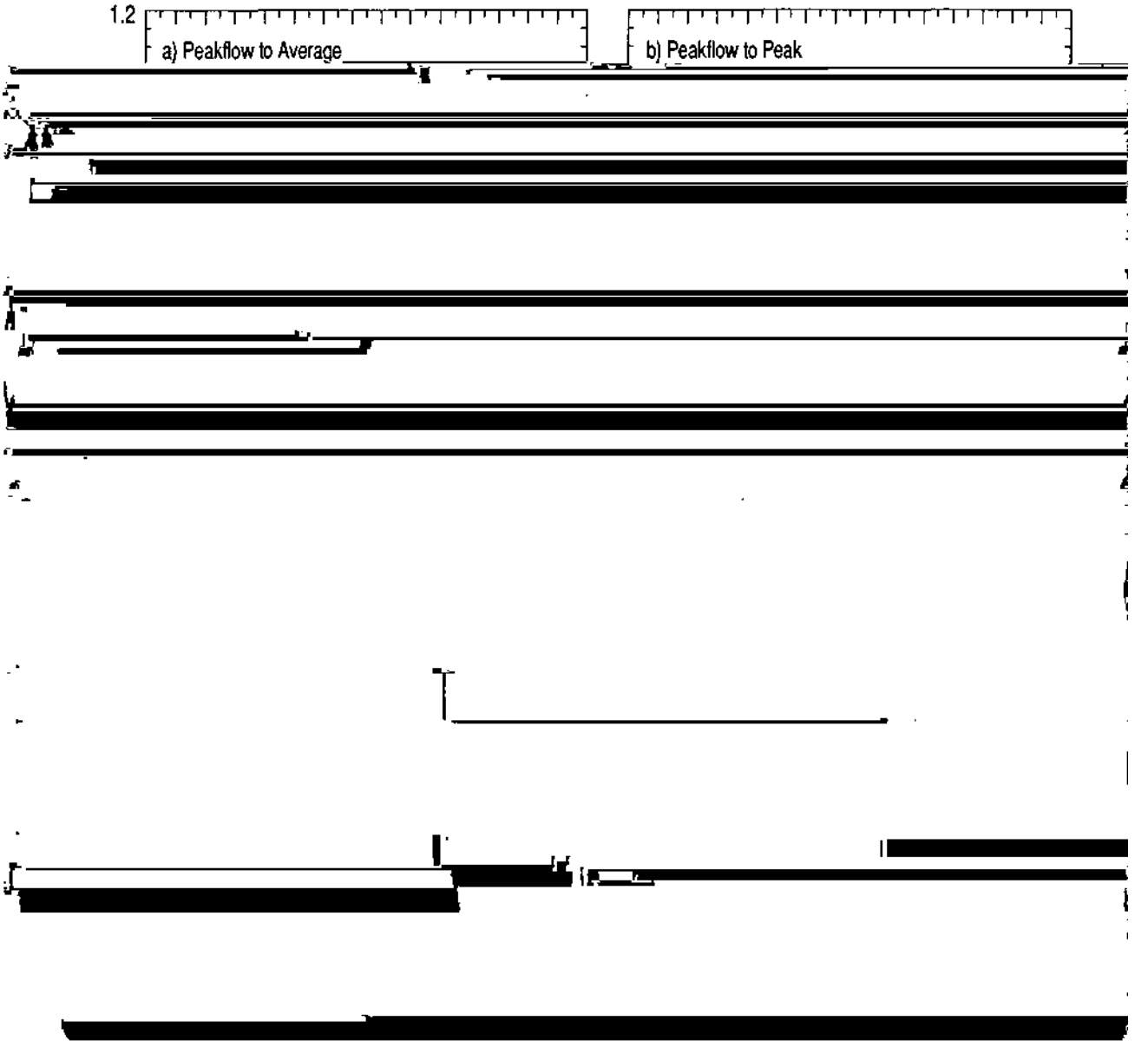

Figure 14. Regional

of wetlands for central and northern Illinois. The peakflow to average precipitation ratio shows the most significant relationship. The percent decreases for central Illinois are 5.9, 4.9, and 5.0 percent for peakflow to average precipitation ratio, peakflow to peak precipitation ratio, and peakflow to total precipitation ratio, respectively. For northern Illinois the decreases for the three peakflow parameters are 7.9, 6.5, and 2.9 percent, respectively.

Table 3. Regional Regression Coefficients and Percent Per.81hhanj0 Tc (e)Tj-0.065 44 0.366 w (Re

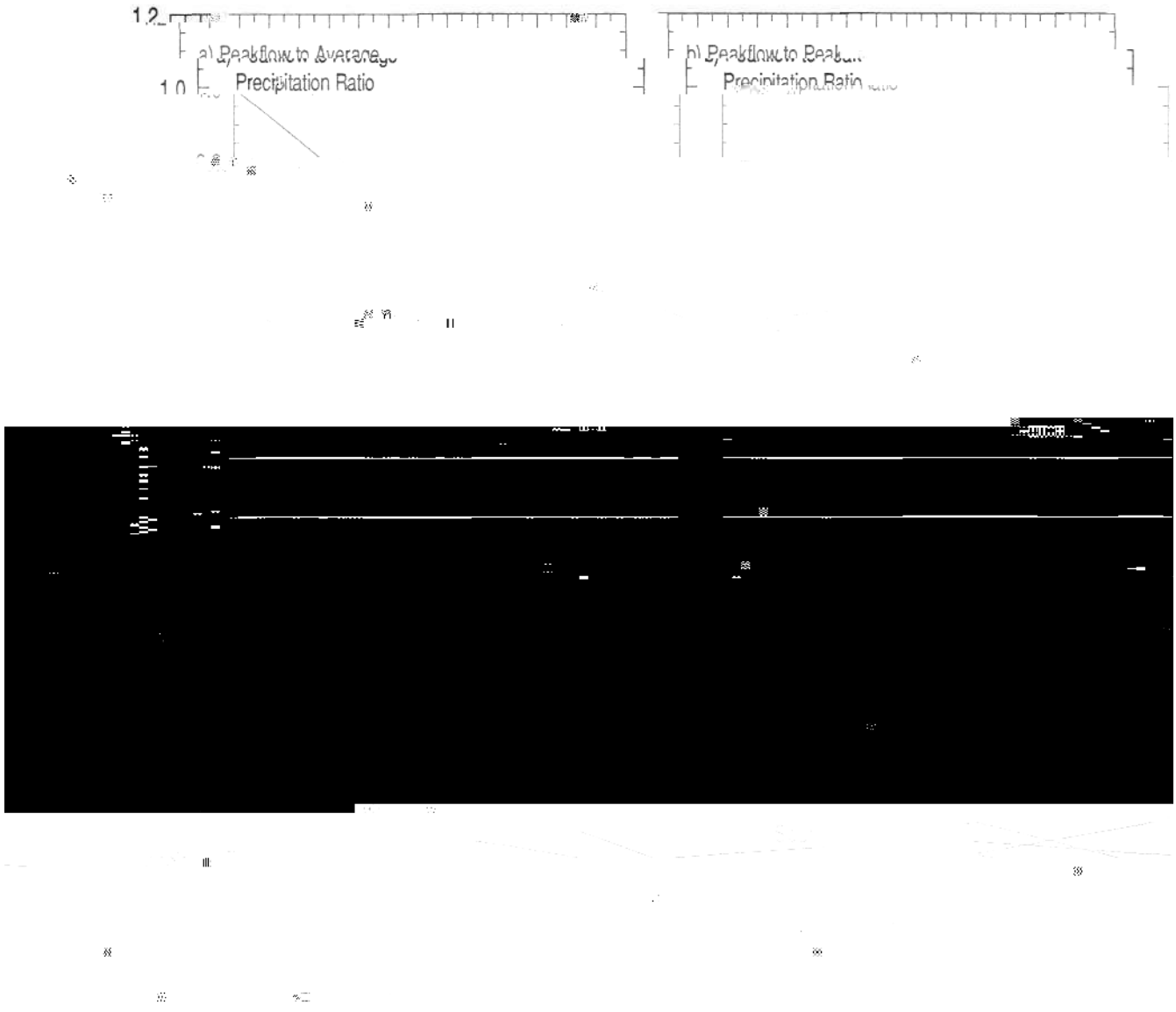

Figure 16. Regional variation of the relations between peakflow and floodflow volume parameters and percent wetland for fall

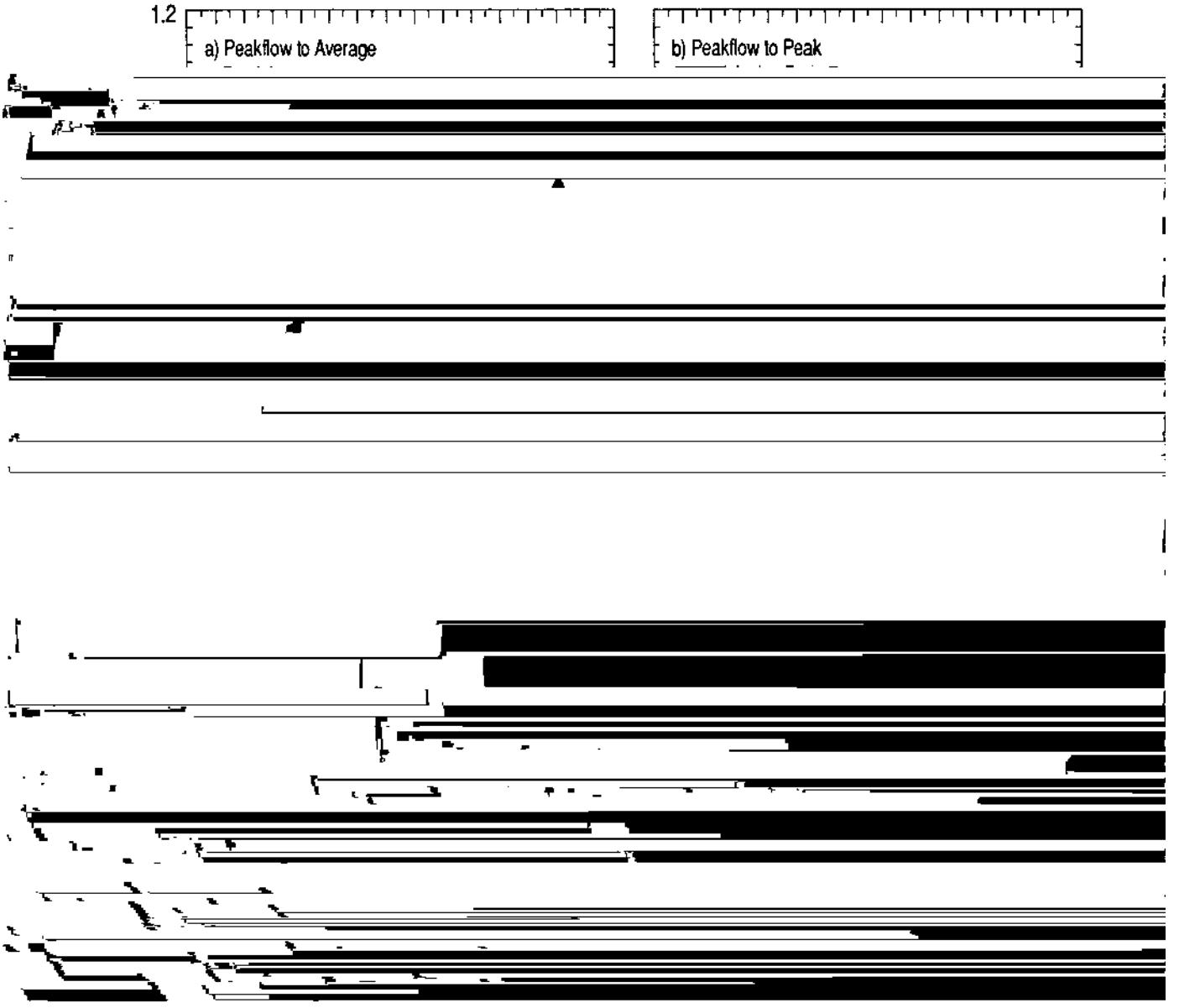

Figure 18. Regional variation of the relations between peakflow and floodflow volume parameters and percent wetland for spring

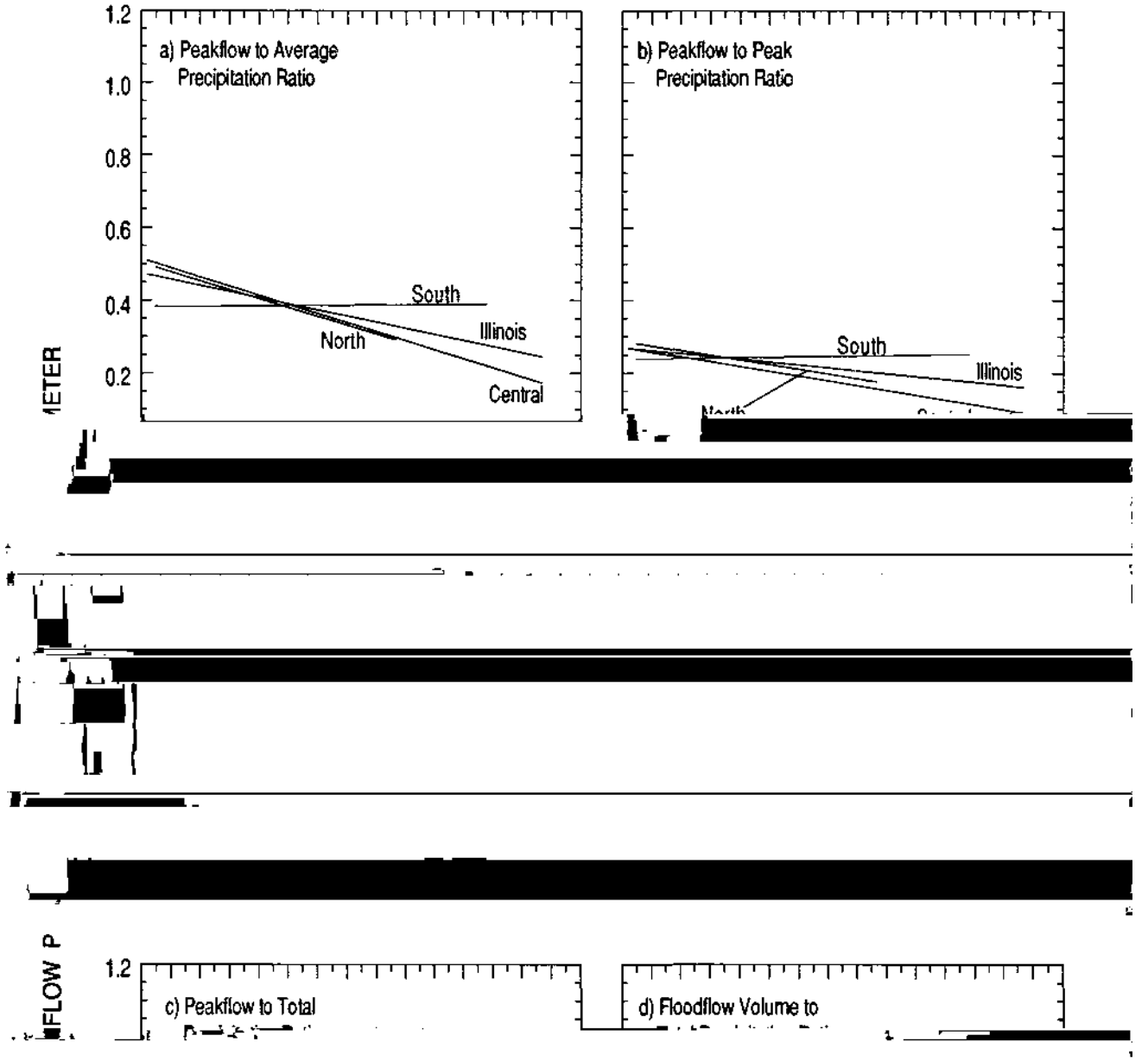

Figure 19. Regional variation of the relations between peakflow and floodflow volume parameters and percent wetland for summer

Table 4. Influence of Wetlands on Peakflow as Measured by the Percent Change in the Ratio of Peakflow to Average Precipitation Ratio (Q_p/P_a) for a One Percent Change in Wetland Area

	Annual	*Fall*	*Winter*	*Spring*	*Summer*
Illinois (statewide)	**-3.7**	**-5.7**	**-2.4**	**-4.0**	**-4.2**
South	+0.8	+1.5	-3.3	-2.9	+0.3
Central	-5.9	-8.7	-4.3	-5.3	-5.9
North	-7.9	-8.2	-1.9	-6.5	-6.1

Table 5. Influence of Wetlands on Peakflow as Measured by the Percent Change in the Ratio of Peakflow to Peak Precipitation (Q_p/P_p) for a One Percent Change in Wetland Area

	Annual	*Fall*	*Winter*	*Spring*	*Summer*
Illinois (statewide)	**-2.6**	**-4.1**	**-1.6**	**-2.8**	**-3.8**
South	1.6	2.7	-3.4	-2.7	+0.5
Central	-4.9	-8.3	-4.0	-3.6	-6.0
North	-6.5	-5.1	0.8	-4.6	-5.5

presented in the following sections. The results of this analysis are provided in figures 16-19 and tables 4-7.

Fall. The results for the fall season are shown in figure 16. The results show that all the peakflow parameters decrease with increasing percentage of wetlands for both central and northern Illinois. The decreases for central Illinois are 8.7, 8.3, and 9.0 percent for peakflow to average precipitation ratio, peakflow to peak precipitation ratio, and peakflow to total precipitation ratio, respectively. The decreases for northern Illinois are 8.2, 5.1, and 6.2 percent, respectively. For southern Illinois, however, the peakflow ratios increase with increasing percentage of wetlands: the increases are 1.5, 2.7, and 2.3 percent, respectively. Among the three peakflow parameters, the most noticeable relationship is for the peakflow to average precipitation ratio. Among the three regions, the relationships for central and northern Illinois are more perceptible.

The floodflow volume parameter exhibits results similar to the peakflow parameters, where the parameter decreases in northern and central Illinois and increases in southern Illinois (figure 16c). The decreases for central and northern Illinois are 6.9 percent and the increase for southern Illinois is 4.4 percent.

Winter. The results for the winter season are summarized in figure 17. The results show that, in general, the peakflow parameters decrease with increasing percentage of wetlands in the watershed for southern and central Illinois. The decreases for southern Illinois are 3.3, 3.4, and 3.5 percent for peakflow to average precipitation ratio, peakflow to peak precipitation ratio, and peakflow to total precipitation ratio, respectively. The decreases for central Illinois are 4.3, 4.0, and 3.0 percent, respectively. For northern Illinois, only peakflow to average precipitation ratio decreases by 1.9 percent, while peakflow to peak precipitation ratio and peakflow to total precipitation ratio increase by 0.8 and 0.9 percent, respectively. Among the three peakflow parameters, the most noticeable relationship is for peakflow to average precipitation ratio. Among the three regions, the relationship for central Illinois is the most perceptible.

The floodflow volume parameter exhibits similar results to those of the peakflow parameters (figure 16d). The floodflow volume to total precipitationes wit

area in the watershed. The corresponding decreases for central Illinois are 5.3, 3.6, and 3.5 percent, and for northern Illinois they are 6.5, 4.6, and 3.8 percent. Among the three peakflow ratios, the most significant relationship is for peakflow to average precipitation ratio. Among the three regions, the relationship for northern Illinois is the most perceptible.

The floodflow volume parameter also decreases with increasing wetland percentage for all three regions fo

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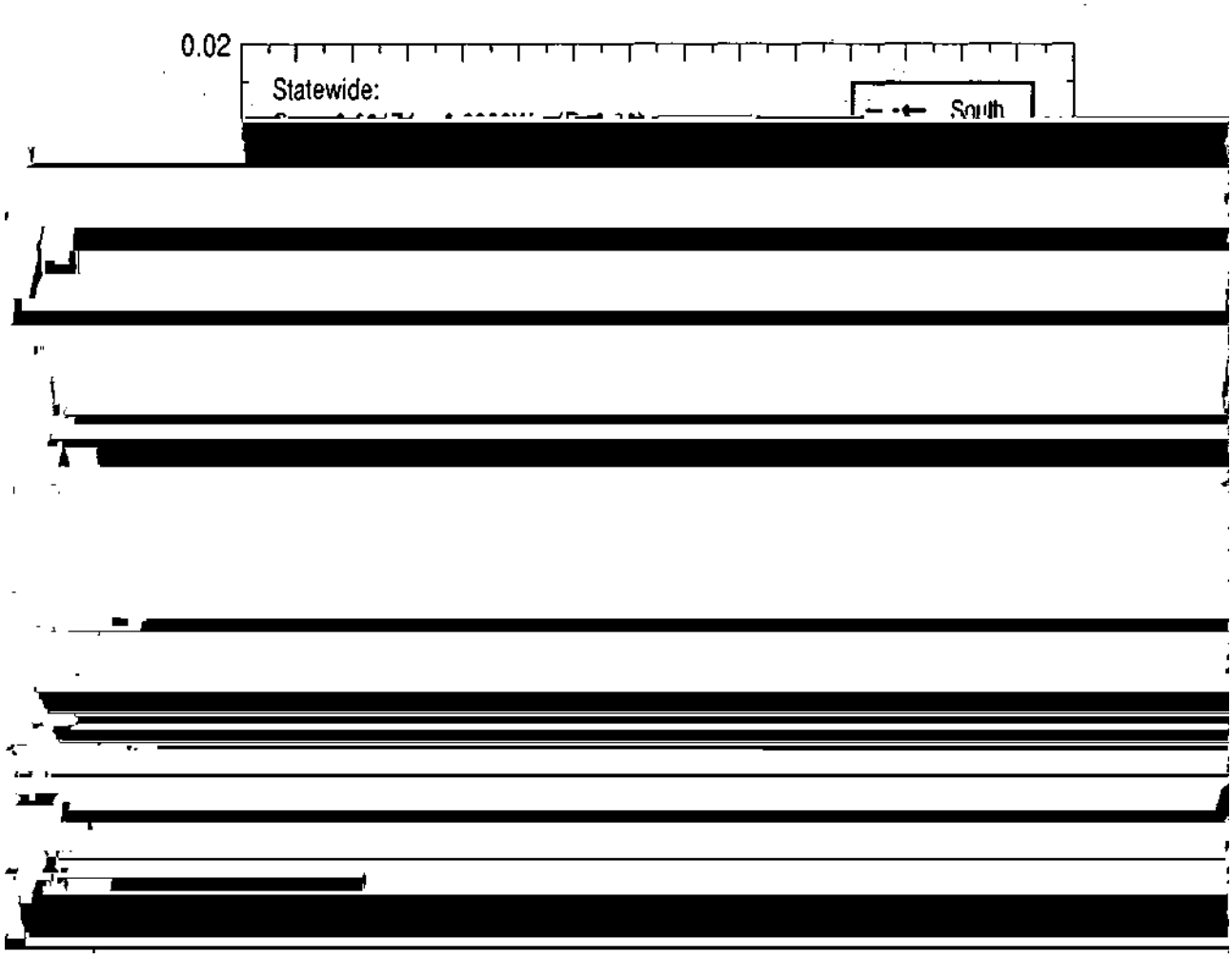

Figure 20. Relation between low-flow parameter, Q_{95}, and percent wetland for Illinois

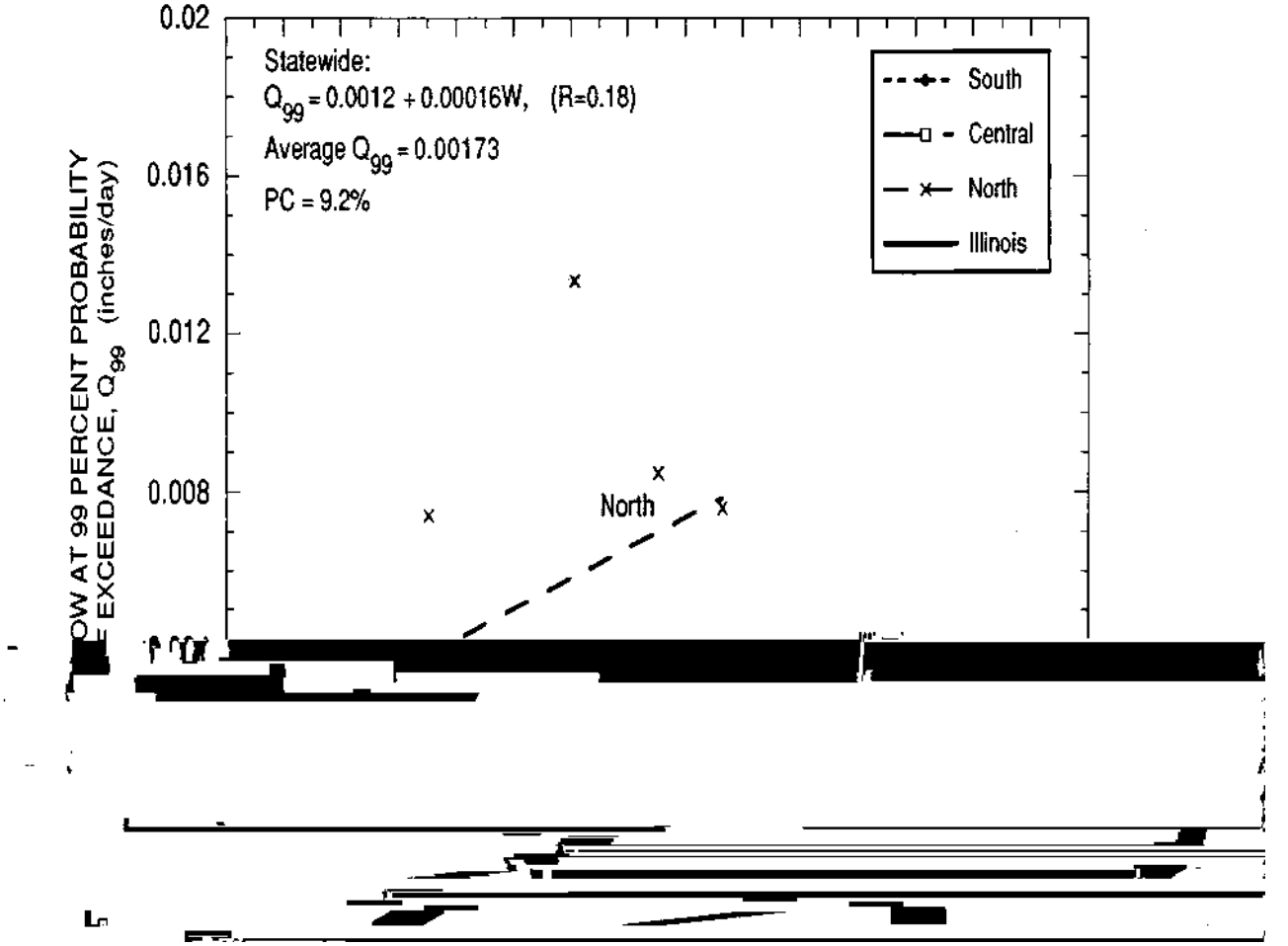

Figure 21. Relation between low-flow parameter, Q_{99}, and percent wetland for Illinois

Table 8. Regional Variability of Influence of Wetlands on Low Flow in Illinois as Measured by the Percent Change in Q_{95} and Q_{99}

	Q_{95} (percent change)	*Q_{99} (percent change)*
Illinois (statewide)	+7.9	+8.4
Southern Illinois	+15.9	+17.2
Central Illinois	+5.5	-4.6
Northern Illinois	+15.0	+18.2

Table 9. Seasonal Variability of Influence of Wetlands on Low Flow in Illinois as Measured by the Percent Change in Q_{95} and Q_{99}

	Q_{95} (percent change)	*Q_{99} (percent change)*
Annual	+7.9	+8.4
Fall	+8.4	+9.2
Winter	+7.6	+7.6
Spring	-1.8	-2.4
Summer	+8.0	+9.4

Notes:
Q_{95} = flow at 95 percent probability of exceedance
Q_{99} = flow at 99 percent probability of exceedance
\+ = parameter value increases with increasing wetland percentage
\- = parameter value decreases with increasing wetland percentage

Regional Analysis

The results from the regional analysis are also shown in figures

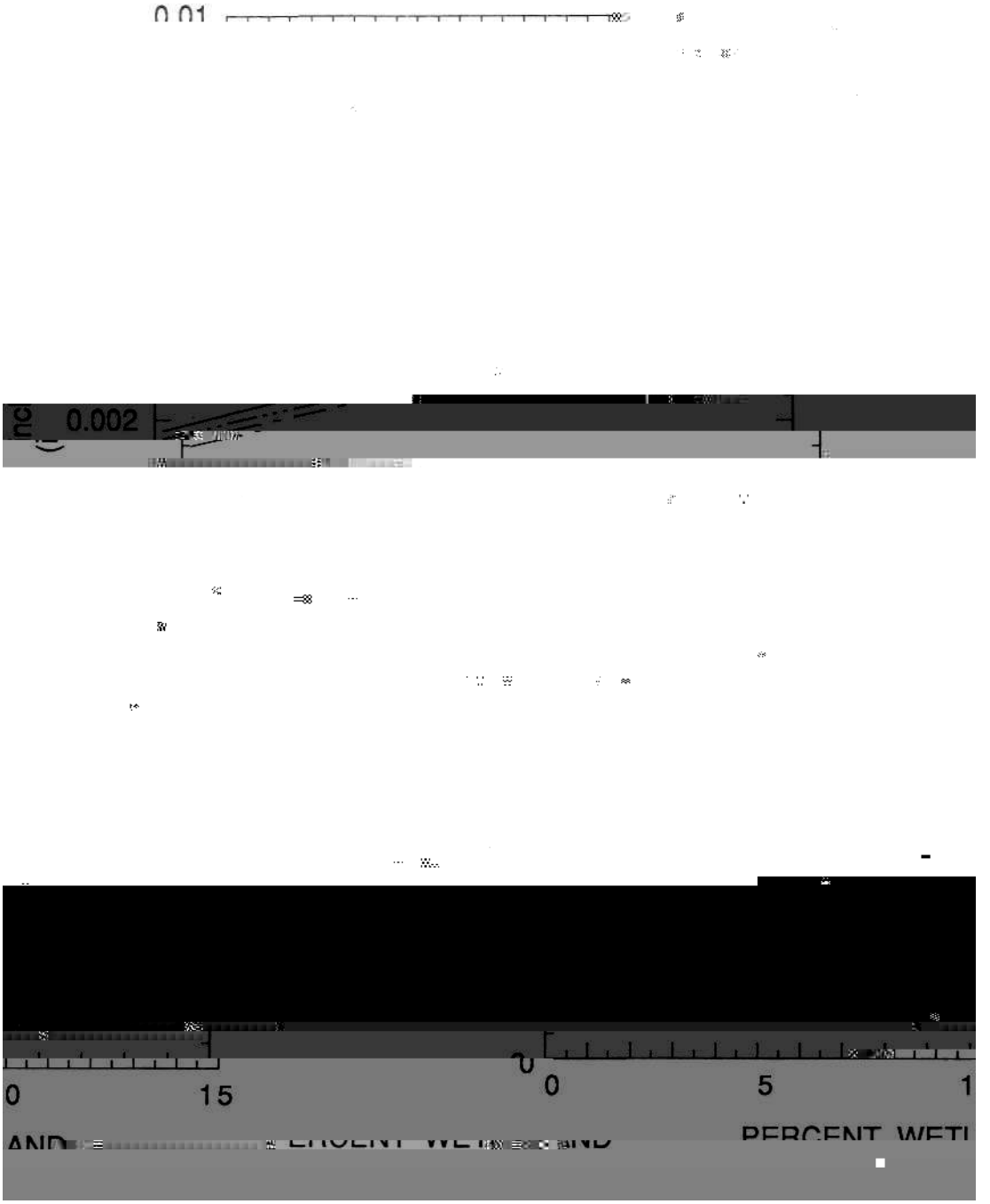

Figure 22. Seasonal variation of the relation between parameters Q_{95} and Q_{99} and percent wetland low flow

for Q_{95} and Q_{99}, respectively. The percent increases for central Illinois are 10.2 and 5.7 percent, respectively. The percent increases for northern Illinois are 12.9 and 14.1 percent, respectively. Thus the relationships for all three regions in Illinois show similar influence of wetlands on low flow for winter. The rate of increase is again higher for northern Illinois than that for either southern or central Illinois.

Spring. The results show that for all three regions - southern, central, and northern Illinois - Q_{95} as well as Q_{99} are influenced much less by9 Tc 1.837 Tw (0630 Tm(norther)Tj0 ln54

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SUMMARY AND CONCLUSIONS

Existing streamflow records from 30 gaging stations in different geographic regions of Illinois with different percentages of wetlands in their watersheds were analyzed to assess the influence of wetlands on streamflow. The objective of the research was to determine if streamflow parameters were influenced by the percentage of wetlands in the 34 Tc 0.59e

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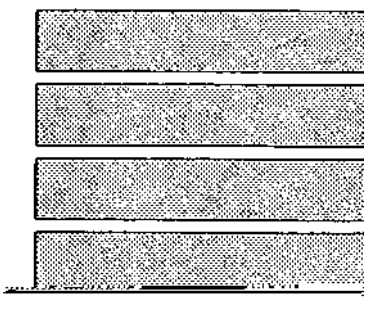
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