Summary of Ambient Monitoring Data Collected from the Snohomish River Basin

by
William Ehinger
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Washington State Department of Ecology
Environmental Investigations and Laboratory Services Program
Ambient Monitoring Section
Olympia, Washington 98504-7710

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INTRODUCTION

This report is intended as a summary of the ambient monitoring data collected in the Snohomish River Basin. The statistical relationships are real but the cause-effect relationships mentioned below are meant to be plausible explanations, which require field corroboration. As specific questions or issues arise, either from this document or after Watershed Assessments Section's (WAS) field investigation begins, then more specific analyses can be initiated. An interactive working relationship between WAS and Ambient Monitoring Section (AMS) will get more use from the ambient monitoring database, while knowledge of and access to data collected by WAS can be helpful in the interpretation of the AMS data.

Monitoring Stations

Long-term monthly records (core stations) are available for seven sites in the Snohomish River Basin: the Snohomish River at Snohomish (07A090), the Pilchuck River at Snohomish (07B055), the Skykomish River at Monroe (07C070) and at Gold Bar (07C120), and the Snoqualmie River near Carnation (07D070) and at Snoqualmie (07D130) (Table 1). In addition, monthly samples were collected at six other sites (rotating stations) during Wateryear 1992: Sultan River at Sultan (07E055), Woods Creek at Monroe (07F055), Snoqualmie River near Monroe (07D050), Tolt River near Carnation (07G070), Raging River at Fall City (07Q070), and Patterson Creek near Fall City (07P070). Flow estimates were not collected at Patterson Creek, Woods Creek, or Snoqualmie River near Monroe.

Table 1. Current core (long-term) sampling stations and Wateryear 1992 rotating stations in the Snohomish River Basin (Water Resource Inventory Area 07).

Site	Station ID	Type	Flow Data	Years*
Snohomish R. @ Snohomish	07A090	Core	Y	29
Pilchuck R. @ Snohomish	07B055	Core	Y	17
Skykomish Drainage				
Skykomish R. @ Monroe	07C070	Core	Y	18
Skykomish R. @ Gold Bar	07C120	Core	Y	26
Woods Cr. @ Monroe	07F055	Rotating	N	3
Sultan R. @ Sultan	07E055	Rotating	Y	13
Snoqualmie Drainage				
Snoqualmie R. near Monroe	07D050	Rotating	N	2
Snoqualmie R. @ Carnation	07D070	Core	Y	18
Snoqualmie R. @ Snoqualmie	07D130	Core	Y	27
Tolt R. near Carnation	07G070	Rotating	Y	12
Patterson C. near Fall City	07P070	Rotating	N	1
Raging R. @ Fall City	07Q070	Rotating	Y	1

* number of years of data collection from Wateryear 1960 to 1992, inclusive. Only post-1978 data were used in the analyses (see text).

General Water Quality and Linear Trend Analyses

Methods

Changes over time in temperature, dissolved oxygen concentration, pH, suspended solids, total phosphorus concentration, ammonia concentration, nitrate+nitrite concentration, and fecal coliform bacteria were assessed at the core stations listed above (Table 1), except for the Snohomish River at Snohomish which was reported in Hopkins (1992). The Seasonal Kendall Test (Hircsh, Slack, and Smith, 1982; van Belle and Hughes, 1984; also see Gilbert, 1987) was used to determine statistical significance of linear trends in the raw data. When significant trends were detected, the analysis was repeated on flow adjusted data or on hour of collection data (dissolved oxygen). Problems were encountered at all sites in the trend analysis of total phosphorus and/or ammonia because many of the recorded values were equal to or less than the analytical detection limit and the detection limits for both laboratory procedures have changed since 1978. Detection limits have generally decreased, but occasional samples which were sent to outside labs may have higher or lower reported detection limits. The end result was that false decreasing trends were detected in total phosphorus and ammonia data and they were ignored. The Seasonal Wilcoxon-Mann-Whitney T-test was used for between site comparisons of nitrate/nitrite and suspended solids concentrations.

All non-parametric tests were conducted using WQHYDRO statistical software (Aroner, 1992). SYSTAT (Wilkinson, 1990) was used for all parametric analyses. A probability level of $P < 0.05$ was used for determining statistical significance of all statistical analyses. Trend analyses and interstation comparisons of core stations were limited to post-WY 1978 data. Numerous graphs were produced to illustrate both statistically significant trends and the seasonal variability of the data over time. These are presented in Appendix A. Box plots of most of the measured parameters collected at all of the long-term stations are presented in Appendix B. The 90^{th} percentiles of selected parameters collected during July through September at the core stations are presented in Appendix C.

<u>Snohomish River at Snohomish (07A090)</u> - High temperatures in July and August, and occasional high fecal coliform counts are the major water quality parameters which may be in violation of state statutes (Hopkins, 1992). Total phosphorus and NH_3 concentrations were low (<0.1 mg/L) and other parameters were unremarkable relative to state standards. Significant trends were detected in turbidity (decreasing), nitrate (decreasing), and fecal coliform (decreasing) (Hopkins, 1992) (Table 2).

<u>Pilchuck River at Snohomish (07B055)</u> - Summer water temperature often exceeded 18°C (Class A standard), but no trend over time was detected (Figure A1). Dissolved oxygen concentration values always exceeded 8 mg/L (Figure A2) and a decreasing trend which was detected in the raw data, did not appear in the flow adjusted data (Figure A3). No trends were detected in pH and nearly all values were within standards (Figure A4). No trends were detected in suspended solids (Figure A5) and concentrations were significantly lower than in the Snohomish. Decreasing trends were detected in both fecal coliform bacteria and nitrate (Figures A6 and A7). Nitrate concentration was significantly higher than in the Snohomish River (Table 3). Fecal coliform values often exceeded 100/100 mL (Figure A6), while total phosphorus and ammonia were usually < 0.1 mg/L.

<u>Skykomish River at Monroe (07C070)</u> - Dissolved oxygen values were always above the standard (Figure A8) and pH rarely was out of the acceptable range (Figure A9), while water temperature occasionally exceeded 18°C (Figure A10), and occasional high fecal coliform counts were recorded (Figure A11). Suspended solids concentration was lower than at the Snohomish River site at Snohomish (Table 3) but no trends were detected (Figure 12). A significant decreasing trend was detected in nitrate at this site (Figure A13 and A14). Nitrate concentration was significantly lower than in the Snohomish River but not different than at the Gold Bar station.

<u>Skykomish River at Gold Bar (07C120)</u> - No serious violations of water quality standards were noted nor were significant trends detected in temperature (Figure A15), dissolved oxygen

Table 2. Results of Seasonal Kendall Test for linear trends. When significant ($P<0.05$) trends in the raw data were detected, the test was repeated on flow adjusted data (raw data results/flow adjusted). (+) = increasing trend, (-) = decreasing trend, ns = not significant, nv = analysis not valid due to changes in detections limits and a high proportion of 'less than' values (see text).

Parameter	Snohomish R.	Pilchuck R.	Skykomish Monroe	Skykomish Gold Bar	Snoqualmie Carnat	Snoqualmie Snoqual
Temperature	-/ns	ns	ns	ns	ns	ns
Dissolved O_2	ns	-/ns	ns	ns	-/*	-/-
pH	ns	ns	ns	+/+	ns	+/*
Susp. solids	+/ns	ns	ns	ns	ns	+/ns
T. phosphorus-P	nv	nv	nv	nv	nv	nv
Nitrate-N	-/-	-/-	-/-	-/-	ns	ns**
Ammonia-N	nv	nv	nv	nv	nv	nv
Fecal coliform	-/-	-/*	ns	ns	ns	ns

* r^2 of flow parameter-flow relationship <0.1, therefore flow adjusted values were not calculated

** significant increasing trend in nitrate-N concentration and in the flow adjusted concentrations was detected during the low flow months (July-October)

Table 3. Results of the Wilcoxon-Mann-Whitney T-test of between site differences in suspended solids and nitrate-N concentrations. Between site comparisons were limited to the those listed below. (+) = the concentration at the station in the column on the far left in significantly greater than at the station listed above, (-) = the concentration at the station in the column on the far left in significantly less than at the station listed above, ns = not significant.

Suspended Solids

Site	Pilch.	Skykomish @ Monr	Skykomish @ G. Bar	Snoqualmie @ Carn	Snoqualmie @ Snoqu
Snohomish R.	+	+	+	+	+
Pilchuck R.		ns		ns	
Skykomish @ Monroe			+	ns	
Snoqualmie @ Carn					ns

Nitrate-N

Site	Pilch.	Skykomish @ Monr	Skykomish @ G. Bar	Snoqualmie @ Carn	Snoqualmie @ Snoqu
Snohomish R.	-	+	+	ns	+
Pilchuck R.		+		+	
Skykomish @ Monroe			ns	-	
Snoqualmie @ Carn					+

concentration (Figure A16), suspended solids (Figure A17), or fecal coliform (Figure A18). An increasing trend was detected in pH (Figure A19) and a decreasing trend was detected in nitrate (Figure A20). Suspended solids values were significantly lower than at the downstream site at Monroe (Table 3).

Snoqualmie River at Carnation (07D070) - A decreasing trend in dissolved oxygen was detected (even after correction for hour of collection) (Table 2), however standards were not violated (Figure A21). Trend analysis was not done on the flow adjusted data due to the poor ($r^2 < 0.1$) relationship with flow. Temperature occasionally exceeded the standard (Figure A22) and pH fell below 6.5 (Figure A23), but overall few violations were noted. Suspended solids (Figure A24) were significantly less than at the Snohomish River site, but did not differ from the Skykomish River at Monroe or from the Snoqualmie River at Snoqualmie. A marginally significant decreasing trend in nitrate ($P < 0.2$) was found to be non-significant after analysis of the flow adjusted concentration (Figure A25). Nitrate concentration was significantly higher than either the Snoqualmie River at Snoqualmie or the Skykomish River at Monroe (Table 3). Fecal coliform counts occasionally exceeded 100/100 mL, but consistent violations of the geometric mean standard were probably not common (Figure A26).

Snoqualmie River at Snoqualmie (07D130) - No violation of any water quality standard was noted. No significant trends were detected in temperature (Figure A27) or fecal coliform (Figure A28). Significant trends were detected in dissolved oxygen (decreasing) (Figure A29), pH (increasing) (Figure A30), and in nitrate during the low flow months, July-October (increasing), (Figure A31). The decreasing trend in dissolved oxygen concentration was present after correction for hour of collection. A seasonal difference in trend direction was detected during a routine trend analysis of nitrate concentration. The seasons (low flow and high flow) were selected *a priori* by a visual examination of the distribution of the flow data at the site. Neither the overall trend in nitrate concentration, nor the trend for the high flow months was significant. Although, a significant trend was detected in suspended solids (A32), an analysis of the flow adjusted concentration was not significant.

Summary

Significant linear trends were detected in nitrate-N concentration at five of the six stations tested. Only one, the Snoqualmie River at Snoqualmie, demonstrated an increasing trend, and only in the low flow months (July-October). Because this trend is a low flow phenomenon, it may indicate an influx of nitrate laden groundwater, irrigation return flow, or a constant, low-mass input, which is diluted (and therefore not detected) at high flows.

Decreasing trends in dissolved oxygen at two of the six stations (Snoqualmie River at Carnation and at Snoqualmie) may be of concern if they continue, but at this time values are above state standards.

Interstation Comparisons of WY 1992 Data

Statistical interstation comparisons of sites with only a single year of data can be misleading because of the natural range of seasonal variability (and correlation with flow) exhibited by these parameters. Interquartile box plots are used here to illustrate the central tendency and range of the data. Because of the variable length of record among stations, the plots are restricted to WY 1992 data, so that the relative differences between stations are not obscured by interannual variation.

Flow data were not collected at Woods Creek, Patterson Creek, or Snoqualmie River near Monroe (Figure 1). There was much overlap in the suspended solids concentration data (Figure 2). Qualitatively, total phosphorus concentration was higher in Patterson Creek and Woods Creek (Figure 3), while nitrate concentration tended to be higher in the Pilchuck River, Woods Creek, and Patterson Creek (Figure 4). Ammonia concentration was low at most sites, but tended to be higher in Patterson Creek, and the Snoqualmie River near Monroe (Figure 5).

Mass Flux Through the Snohomish River System

Methods

Mass flux (constituent mass/time) of suspended solids, total phosphorus-P, nitrate/nitrite-N, and ammonia-N at each sampling station was calculated as the product of concentration (constituent mass/water volume) and flow (water volume/time). The relationship of mass flux past a station versus the sum of the mass flux of all stations directly upstream (*i.e.*, next station upstream on the mainstem river plus all tributaries to the river reach between the two mainstem stations) was used to evaluate net changes in flow and in the flux of suspended solids and nutrients within a river reach. A linear model:

$$Y(a) = b_0 + b_1 * X(a) \qquad (1)$$

where: $Y(a)$ = mass flux of constituent a at the downstream station; $X(a)$ = mass flux of constituent a into the river reach above Station Y (or the sum of upstream station plus tributaries to the mainstem river between the two mainstem stations); b_0 = constant; and b_1 = regression slope, was used. If there were no substantial inputs of a between the monitored stations, and a is conservative (no net losses or gains due to sedimentation or biological activity), then b_0 should equal 0 and b_1 should equal 1. If $b_0 > 0$, then a non-flow related (relatively constant) unmeasured input to the river reach may be occurring. If $b_1 < 1$, then a net loss of a is occurring (*i.e.*, sedimentation, biological uptake, etc.). If $b_1 > 1$, then a net gain of a is occurring which is probably associated with high flow conditions (via unmeasured tributaries or runoff).

Because our sampling methodology (surface grab samples versus horizontally and vertically integrated samples) underestimates particulate constituents, these flux estimates of suspended sediments and total phosphorus are not adequate for loading calculations. Also, the parameters analyzed are not conservative; however, this analysis can indicate river reaches where significant net increases in loading may be occurring. A visual analysis of regression residuals was done and when warranted, outliers were deleted from the data set. These cases are noted in the text. I refrained from deleting cases from the single year data sets (n=12) because of the large influence a case could have on the analysis.

Snohomish River at Snohomish Versus Sum of the Pilchuck River at Snohomish, the Skykomish River at Monroe, and the Snoqualmie River at Carnation

The regression of flow in the Snohomish River at Snohomish versus the sum of flow in the Pilchuck River, Skykomish River at Monroe, and Snoqualmie River at Carnation (Table 4) over all years of record revealed that b_0 was not significantly different from 0 and b_1 was not

Table 4. Results of regression analysis of flow and mass flux at the Snohomish River at Snohomish versus the sum of the inputs from the Pilchuck River at Snohomish, the Skykomish River at Monroe, and the Snoqualmie River at Carnation for all available years of data and for WY 1992 (all years/WY 1992) are presented below. ns = not significant

Variable	b_0	b_1	P	r^2	n
Flow	ns/ns	1.01/1.03	**/**	.96/.88	168/12
Sus Solids	ns/ns	0.92*/0.88	**/*	.94/.67	154/11
T. Phosphorus	142/ns	0.97/1.55	**/**	.90/.89	148/12
Nitrate-N	ns/ns	1.44+/1.42	**/**	.96/.98	158/12
Ammonia-N	228/ns	1.16+/1.14	**/*	.76/.66	153/11

* $P<0.001$
** $P<0.0005$
\+ b_1 is significantly different from 1

different from one. This indicates that measured upstream flows account for nearly all of the measured flow at this point. The WY 1992 data show the same results. Visually, the largest differences in mean flows are seen in June, November, and December (Figure 6). The suspended solids flux regression coefficient (b_1) for all years was significantly < 1 and $b_0 = 0$, suggesting a lower flux at the Snohomish River station compared to inputs from above, probably due to sedimentation or a conversion of suspended solids to bed load at lower water velocities. Regression coefficients of the WY 1992 data and all years of data were not significantly different from each other; however, b_1 in the WY 1992 equation did not differ from 1, probably due to the smaller sample size. Monthly mean suspended flux input was generally lower than output (Figure 7), particularly in February, June, November, and December. Total phosphorus coefficients for all data suggest an increase in phosphorus flux at the lower site ($b_0>0$) that is not associated with increased flux from upstream ($b_1=1$). Comparison of mean inputs and outputs by month confirm this (Figure 8). Phosphorus flux at the Snohomish River site was generally higher than measured input. Wateryear 1992 data do not support this ($b_0= 0$, $b_1>$ 1), but the presence of two outliers in the data set and small sample size influenced the results. After deletion of two extreme outliers from the long-term nitrate/nitrite data set, regressions of both long-term and WY 1992 data produced identical results, $b_0 = 0$ and $b_1 > 1$, with no significant difference between the b_1 values. This may indicate that the source of additional nitrate to this reach is not constant ($b_0= 0$), but appears to be associated with high flows. Figure 9 shows that the difference between input and output does increase with input. Likely explanations include both runoff and discharge from ungauged tributaries during rainy periods. Ammonia flux regression coefficients were not significantly different between the long-term data and WY 1992, although for WY 1992 b_0 was not significant and b_1 was not significantly different from 1. These results suggest a constant ammonia source and possibly a flow related source (runoff or tributaries). A comparison of mean ammonia input versus output shows that mean output always exceeded mean input and that the difference tended to increased as input increased (Figure 10).

Regressions of data collected from July through October (low flow months) were relatively weak (lower r^2 values), but the results were similar (Table 5). Neither b_0 (=0) nor b_1 (=1) values from the summer regression of flow differed from the whole data set estimates (Table 4). A regression of suspended solids inputs versus output to this reach was not statistically significant (b_1=0), possibly reflecting higher sedimentation rates with low water velocities. Total phosphorus b_0 was >0, suggesting a source of phosphorus that is not related to high flow, but b_1< 1. This could be explained by higher summer sedimentation rates (lower flow) or biological uptake (higher temperature, increased light). The regression of ammonia flux, although statistically significant, explained a minute proportion of the variance (r^2=0.07) and so it was ignored.

Skykomish River at Monroe Versus Sum of Flux from Skykomish River at Gold Bar plus Sultan River

Data for the Sultan River were only collected during WY 1992 and so this analysis is limited to that year. This analysis is complicated by the fact that the sampling site for the Skykomish River at Monroe is located upstream of Woods Creek (for which no flow data were collected), but the gauging station is just below the confluence of Woods Creek with the Skykomish. Although Woods Creek is small, relative to the Skykomish River, this situation should be considered.

The regression of flow at Monroe versus the sum of the measured flows at Gold Bar and from Sultan River (Table 6) indicated that other tributaries did not contribute substantially to flow (b_0= 0, b_1= 1) (Figure 11). Suspended solids flux increased substantially downstream at high flows (b_1= 1.70), which suggests a contribution from ungauged tributaries at high flows or runoff (Figure 12). The total phosphorus flux regression revealed a non-significant constant (b_0=0) and a marginally significant (P<0.1) b_1 coefficient. Contributions of total phosphorus to this stream reach (like suspended solids with which phosphorus is often associated) may increase with higher flows (Figure 13), but this relationship is not strong and may be related to Woods Creek inflow. The relationship between nitrate flux into and out of this reach is not as strong as for the other parameters (r^2= 0.53) due to the presence of an outlier (Figure 14), but it appears that nitrate flux increases with increased flow. Ammonia outflow was lower than measured inflow (b_1< 1), suggesting that a net loss is occurring (nitrification or volatilization) (Figure 15). Ammonia concentration was often at or near the detection limits, and so this relationship is probably not important.

Table 5. Results of regression analysis of flow and mass flux at the Snohomish River at Snohomish versus the sum of the inputs from the Pilchuck River at Snohomish, the Skykomish River at Monroe, and the Snoqualmie River at Carnation for the low flow months (July-October) only are presented below. ns = not significant

Variable	b_0	b_1	P	r^2	n
Flow	ns	0.96	<0.0005	.72	53
Sus Solids	ns	0.09*+	ns		48
T. Phosphorus	77	0.61*+	<0.0005	.34	46
Nitrate-N	ns	1.14	<0.0005	.38	50
Ammonia-N	ns	0.97	<0.05	.07	49

* b_1 is significantly different from 1
\+ b_1 is significantly different from slope calculated from all available data

Table 6. Results of regression analysis of flow and mass flux at the Skykomish River at Monroe versus the sum of the inputs from the Sultan River at Sultan and the Skykomish River at Gold Bar are presented below. ns = not significant

Variable	b_0	b_1	P	r^2	n
Flow	ns	1.03.	<0.0005	.95	12
Sus Solids	ns	1.70*	<0.0005	.99	12
T. Phosphorus	ns	1.21	<0.0005	.93	12
Nitrate-N	ns	0.70	<0.005	.53	12
Ammonia-N	ns	0.68*	<0.0005	.83	12

* b_1 is significantly different from 1

<u>Snoqualmie River at Carnation Versus Sum of Flux from the Snoqualmie River at Snoqualmie, the Tolt River at Carnation, and Raging River at Falls City</u>

The regression of flow at Carnation versus the sum of the measured inflows indicate that substantial, additional inflow occurs when flows are high, ($b_1 > 1$) (*i.e.*, rainy season), but that ungauged tributary contributions to this reach are minimal during low flows (Table 7). Differences between measured inflow and outflow tend to increase with higher flows (Figure 16). There appears to be a substantial loss of suspended solids downstream compared

Table 7. Results of regression analysis of flow and mass flux at the Snoqualmie River at Carnation versus the sum of the inputs from the Tolt River near Carnation, Raging River at Fall City, and the Snoqualmie River at Snoqualmie are presented below. ns = not significant

Variable	b_0	b_1	P	r^2	n
Flow	ns	1.10*	<0.0005	.998	12
Sus Solids	ns	0.60*	<0.0005	.995	12
T. Phosphorus	ns	0.78*	<0.0005	.91	12
Nitrate-N	ns	1.30*	<0.005	.997	12
Ammonia-N	ns	0.96	<0.0005	.96	12

* b_1 is significantly different from 1

to input ($b_1 < 1$) when flux is high (Figure 17) and probably reflects sedimentation in this low gradient reach of river. Similarly, the regression coefficient (b_1) in the total phosphorus equation was significantly less than 1, possibly because of sedimentation (Figure 18). Nitrate outflow increased at a faster rate than inflow ($b_1 > 1$) in this reach also, probably a result of rainy season runoff and tributary contributions (Figure 19). Ammonia fluxes revealed no significant differences between input and output ($b_0 = 0$ and $b_1 = 1$) and Figure 20 shows that the relationship between input and output varied.

Flux Estimates Calculated for the Snoqualimie River Near Monroe

In order to indentify the river reach between the Snohomish River at Snohomish and the Snoqualmie River at Carnation where substantial inputs occurred, flux estimates were calculated for the Snoqualmie River near Monroe. Because flow was not measured at the Snoqualmie River near Monroe, flow estimates were calculated as the difference between the measured flow at the USGS gauging station on the Snohomish River near Monroe and the Skykomish River at Monroe.

The regression of suspended solids flux in the Snoqualmie River near Monroe versus the Snoqualmie River at Carnation (Table 8; Figure 21) showed a non-significant b_0 and $b_1 > 1$, suggesting that the increase in suspended solids load between these stations is flow related. Similar results were obtained with the analysis of total phosphorus and nitrate (Figures 22 and 23). Substantial increases in the flux of each of these parameters occurred in this river reach at high flows ($b_1 > 1$). Ammonia flux did not change significantly (Figure 24).

The flux estimates calculated for the Snoqualmie River near Monroe were added to the inputs from the Skykomish River and the Pilchuck River, and then compared with the Snohomish River at Snohomish station to evaluate changes in flux over this river reach. The results of this analysis were very similar to the results for WY 1992 presented in Table 4 (Table 9). The constant (b_0) was non-significant in all of the regressions, and b_1 differed significantly (was less than) from the WY 1992 results (Table 4) only for nitrate. The slope (b_1) in both the total phosphorus and nitrate regressions was significantly greater than one, suggesting substantial, high flow related increases in flux are occurring over this river reach.

SUMMARY

A substantial increase in the flux of nitrate, total phosphorus and ammonia seemed to occur above the Snohomish River station which was not accounted for by the long-term measured inputs from the Pilchuck River at Snohomish, the Skykomish River at Monroe, and the Snoqualmie River at Carnation. The increase in both total phosphorus and ammonia was seemed to be independent of flow and may represent a relatively constant input. The increase in the flux of nitrate and ammonia was positively related to flow, suggesting runoff or increased ungauged tributary contributions. The water 1992 data support the conclusion of a flow related increase in nitrate flux over this river reach, but do not directly support the conclusions for the other parameters. These differences are probably due to the small sample size and to natural interannual variability.

Table 8. Results of regression analysis of mass flux at the Snoqualmie River near Monroe versus the Snoqualmie River at Carnation for WY 1992. ns = not significant

Variable	b_0	b_1	P	r^2	n
Sus Solids	ns	1.45*	<0.0005	.99	12
T. Phosphorus	ns	1.58*	<0.0005	.97	12
Nitrate-N	ns	1.40*	<0.0005	.98	12
Ammonia-N	ns	1.23	<0.0005	.77	12

* b_1 is significantly greater than 1

Table 9. Results of regression analysis of mass flux at the Snohomish River at Snohomish versus the sum of the inputs from the Pilchuck River at Snohomish, the Skykomish River at Monroe, and the Snoqualmie River near Monroe for WY 1992. ns = not significant

Variable	b_0	b_1	P	r^2	n
Sus Solids	ns	.80	<0.0005	.68	11
T. Phosphorus	ns	1.34*	<0.001	.91	12
Nitrate-N	ns	1.20*	<0.0005	.98	12
Ammonia-N	ns	1.10	<0.0005	.77	11

* b_1 is significantly greater than 1

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FIGURES

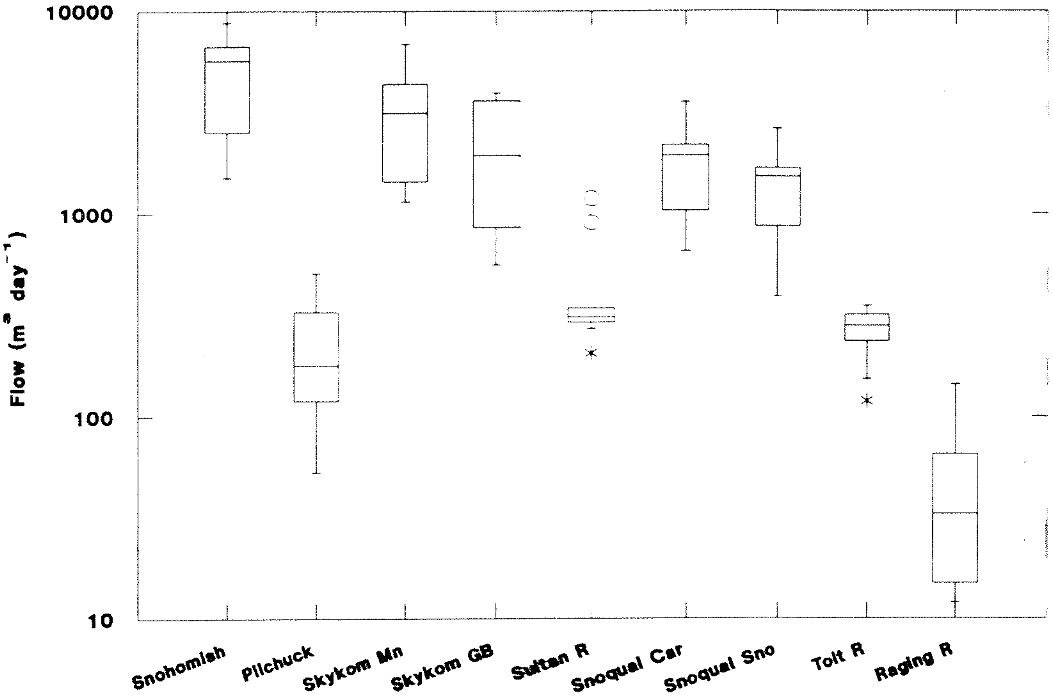

Figure 1. Flow distribution by station for WY 1992.

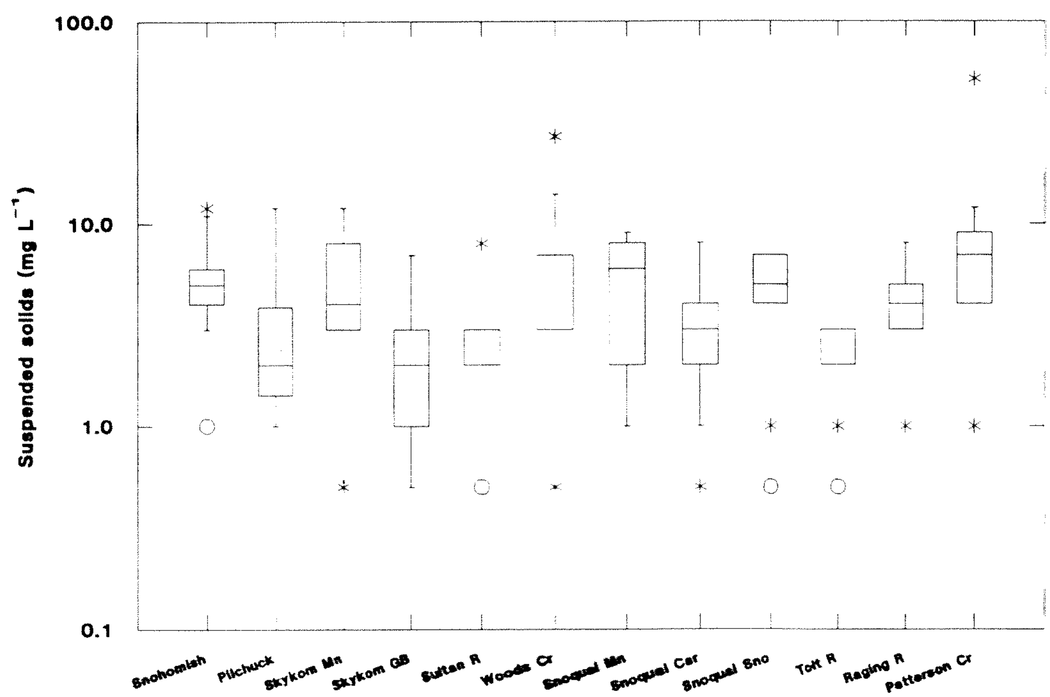

Figure 2. Suspended solids concentration distribution by station for WY 1992.

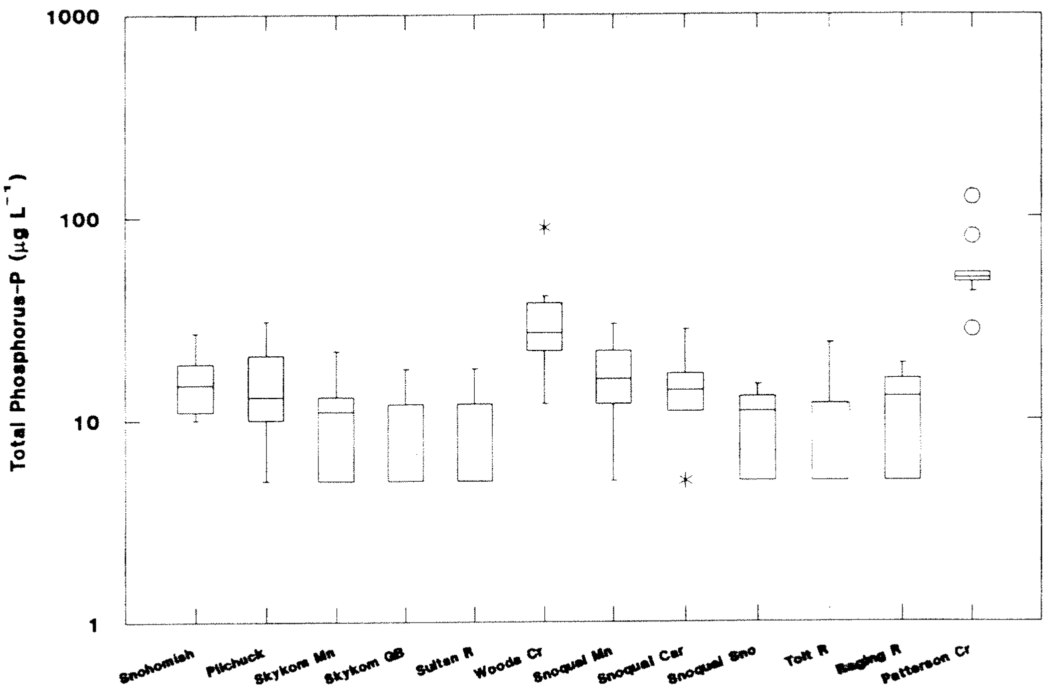

Figure 3. Total phosphorus concentration by station for WY 1992.

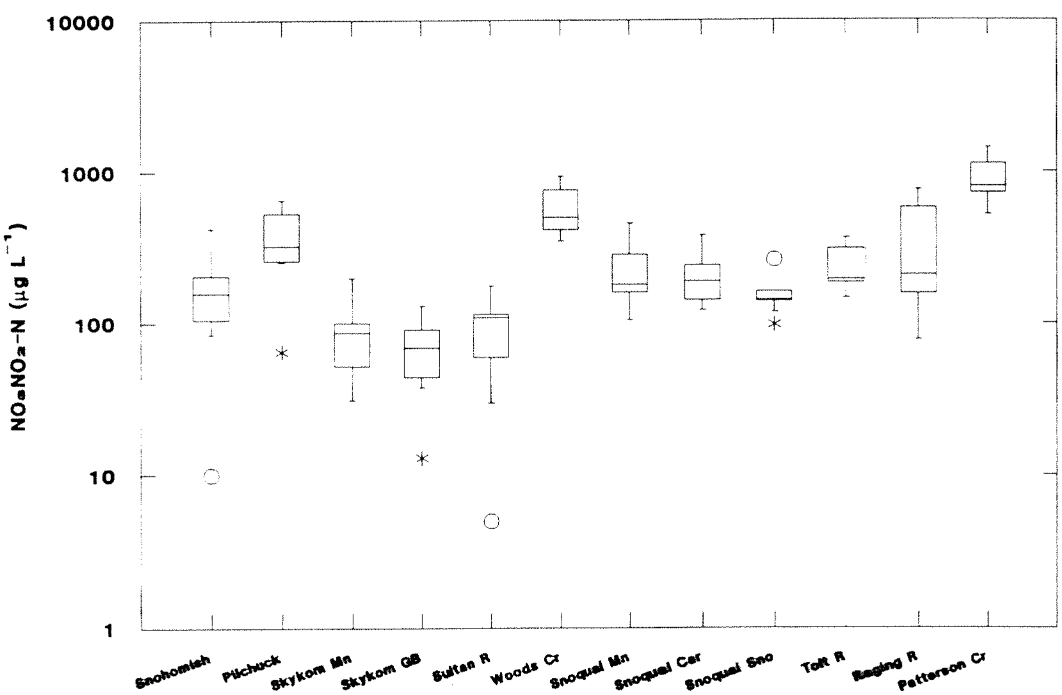

Figure 4. Nitrate-N concentration distribution by station for WY 1992.

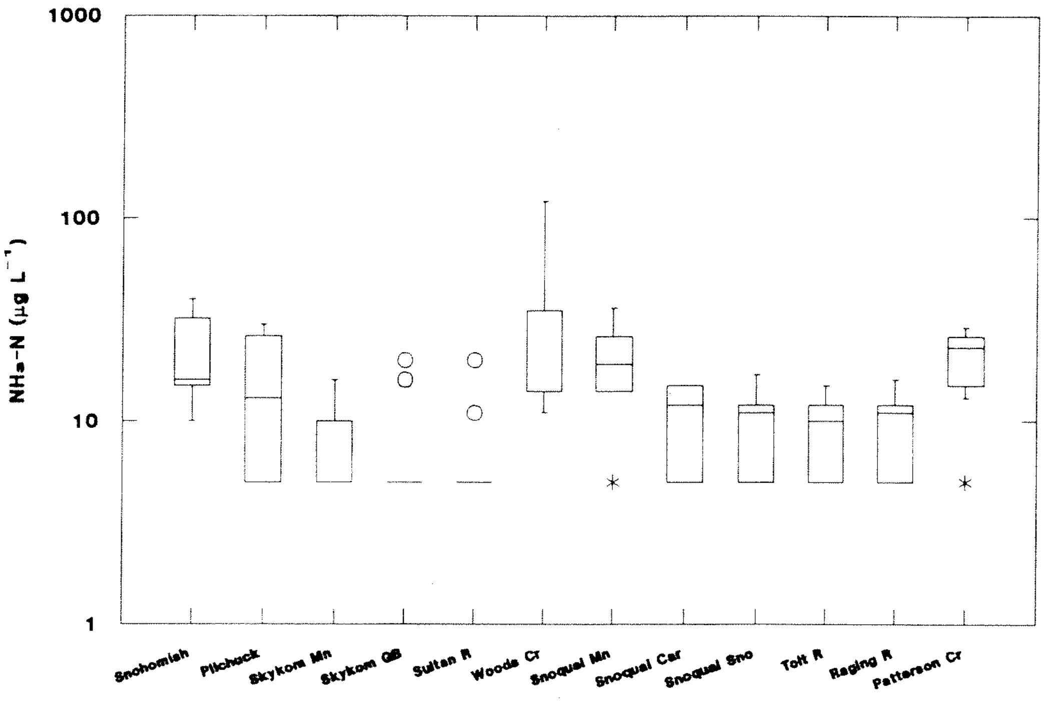

Figure 5. Ammonia-N concentration by station for WY 1992.

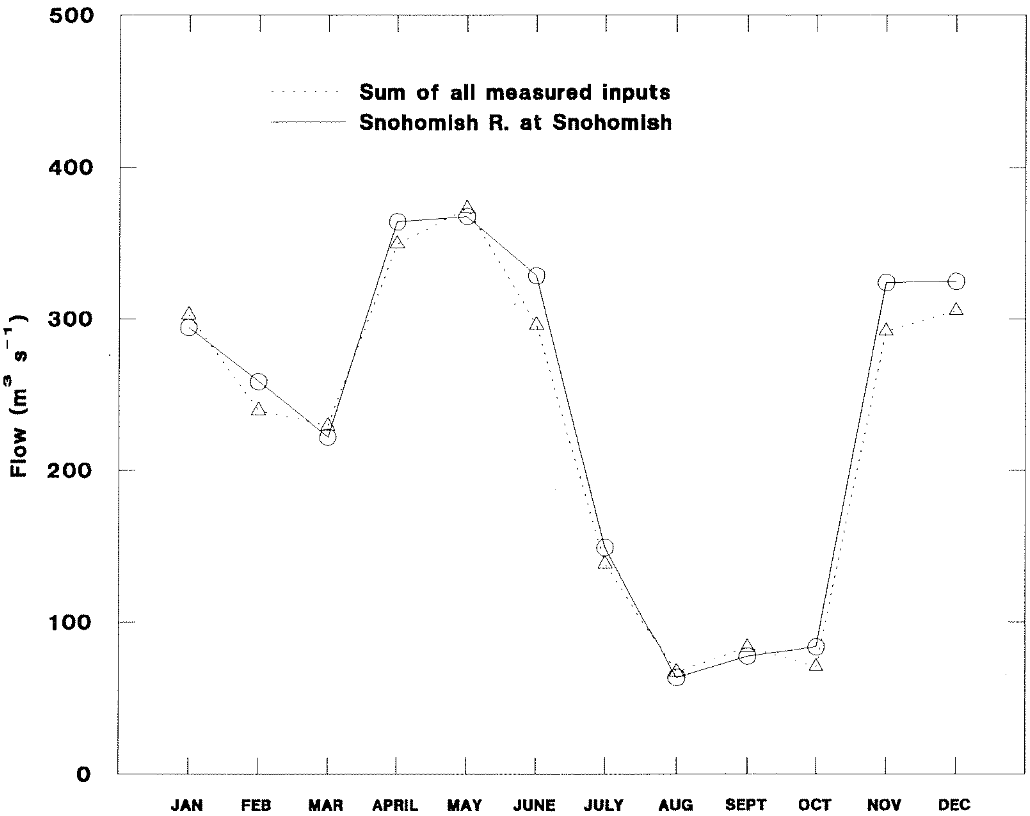

Figure 6. Mean flow measured at the Snohomish River compared to the sum of measured inputs from the Snoqualmie, Skykomish, and Pilchuck rivers.

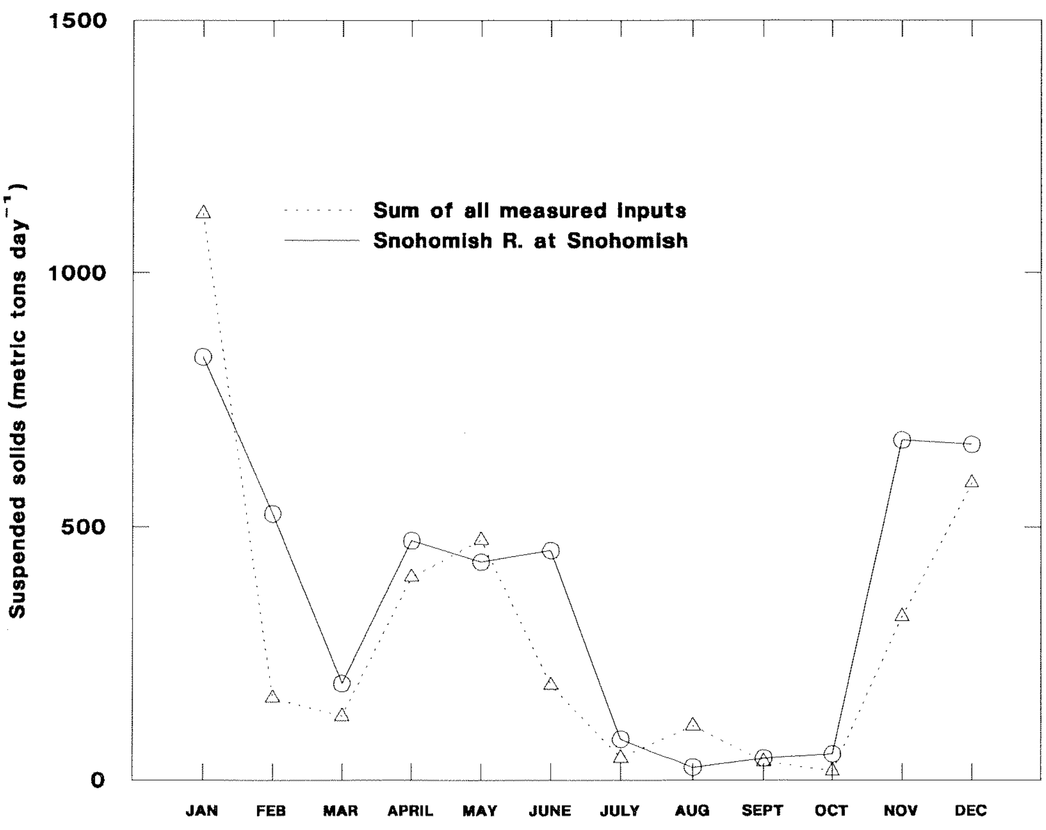

Figure 7. Mean daily flux of suspended solids measured at the Snohomish River compared to the sum of measured inputs from the Snoqualmie, Skykomish, and Pilchuck rivers.

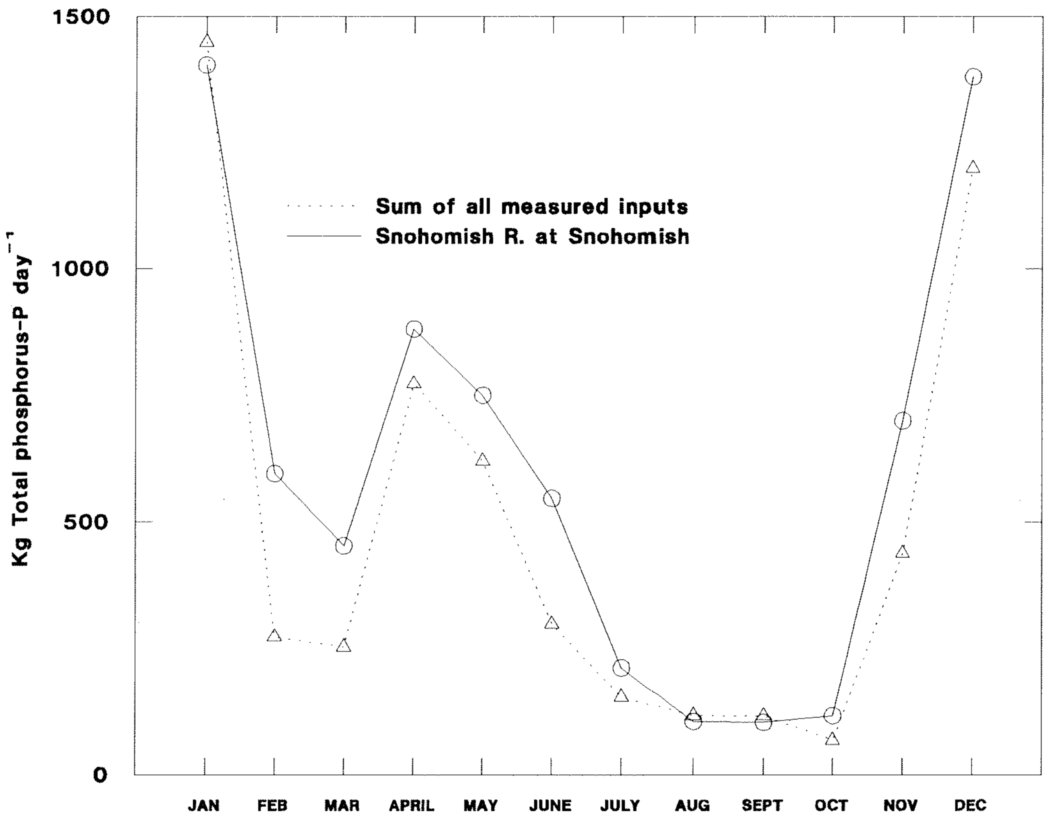

Figure 8. Mean daily flux of total phosphorus measured at the Snohomish River compared with the sum of the measured inputs from the Snoqualmie, Skykomish, and Pilchuck rivers.

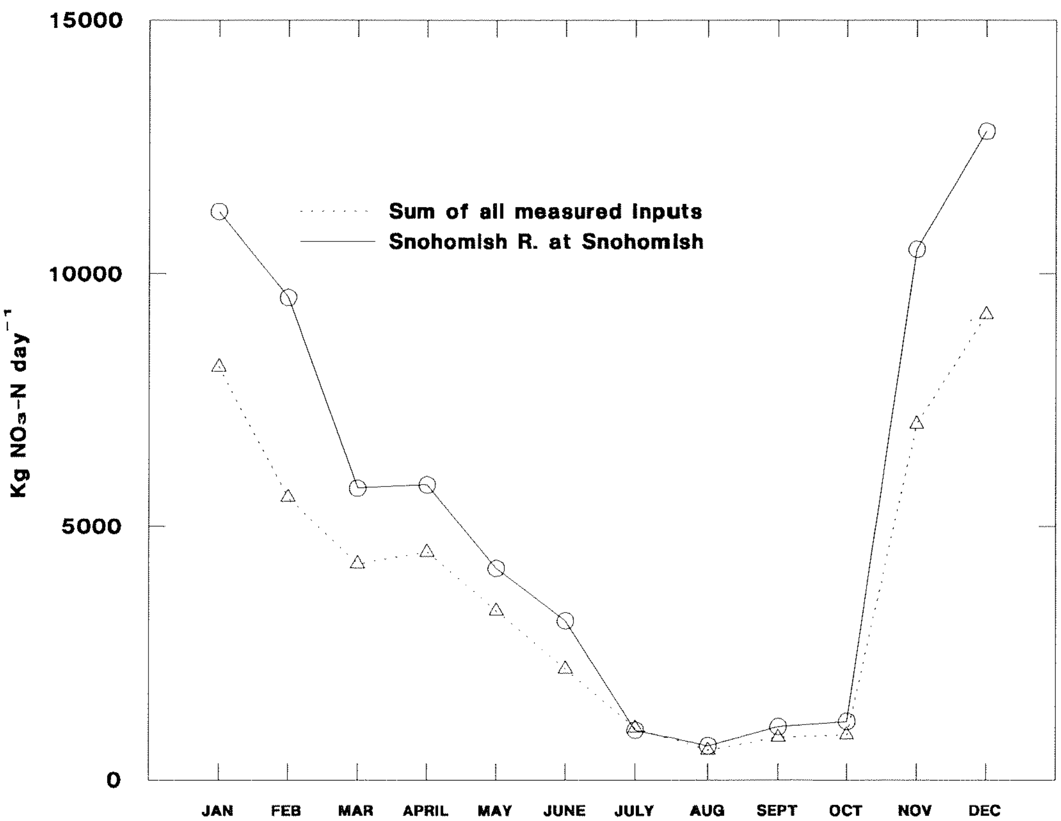

Figure 9. Mean daily nitrate-N flux measured at the Snohomish River compared with the sum of the measured inputs from the Snoqualmie, Skykomish, and Pilchuck rivers.

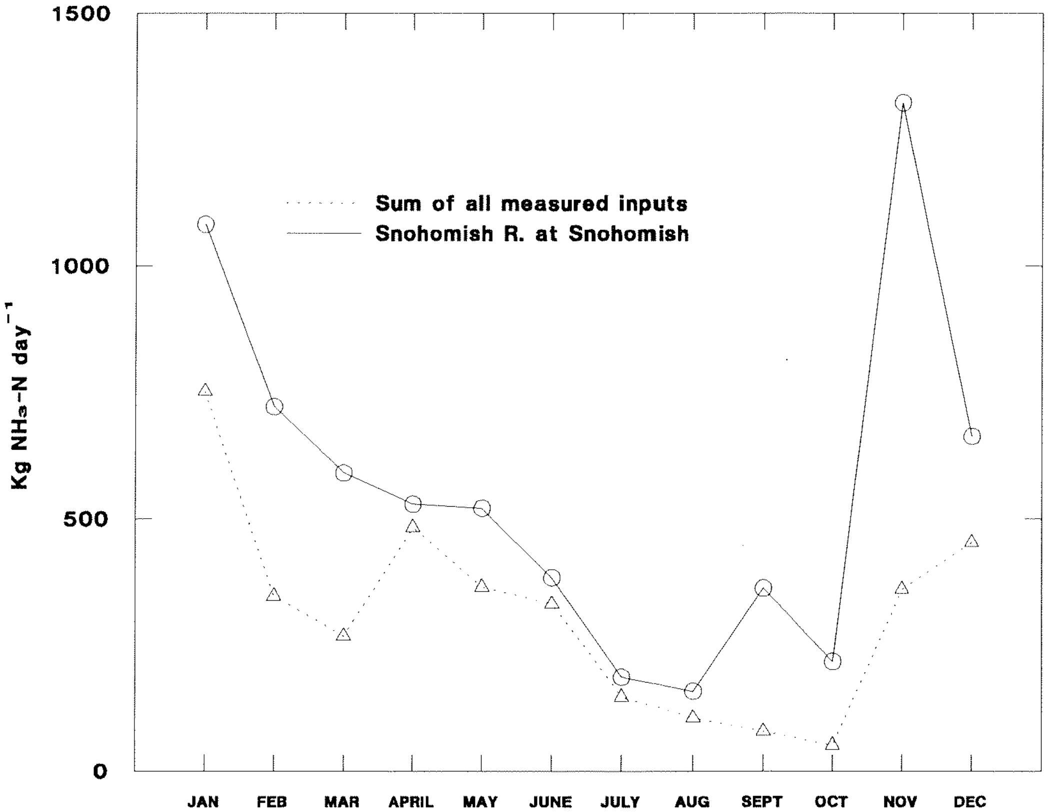

Figure 10. Mean daily ammonia-N flux measured at the Snohomish River compared with the sum of the measured inputs from the Snoqualmie, Skykomish, and Pilchuck rivers.

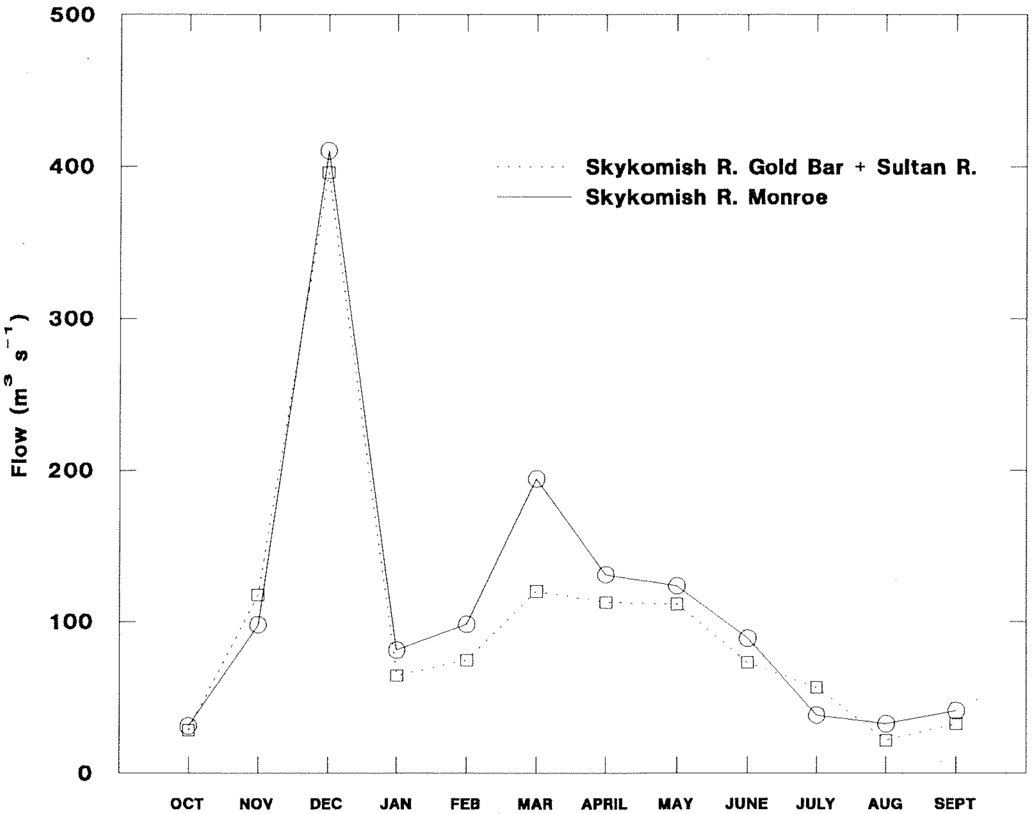

Figure 11. Flow measured at the sites listed above in Wy 1992.

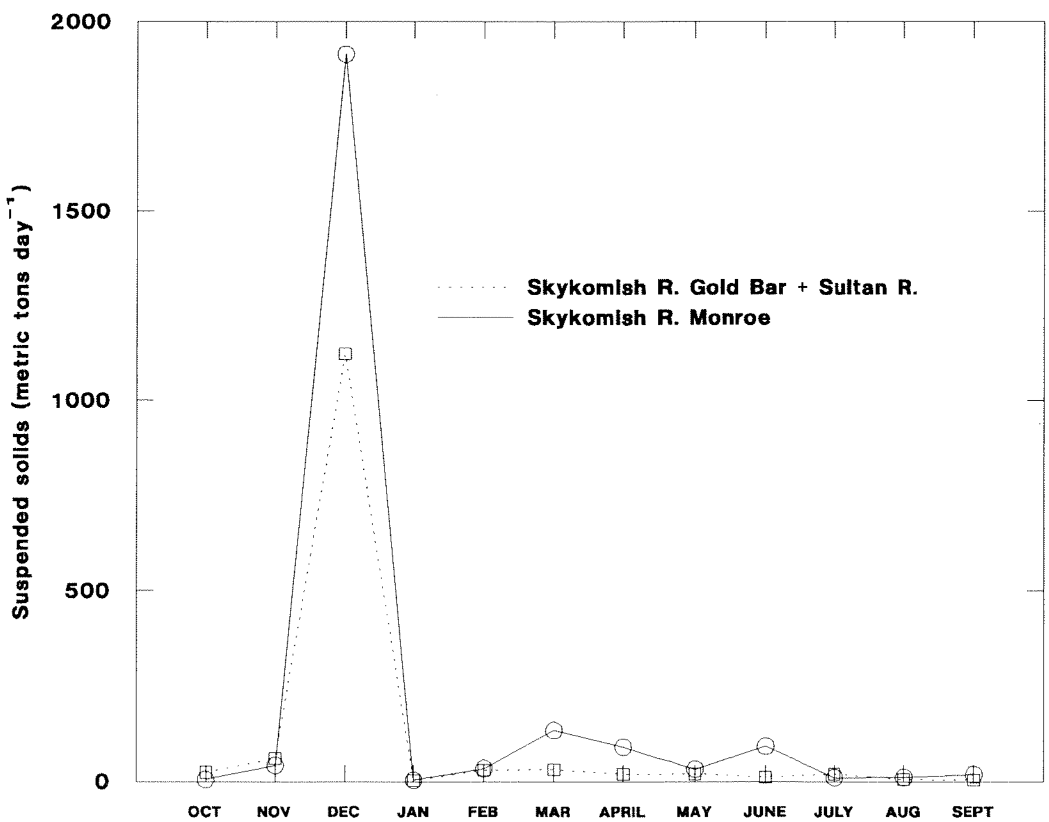

Figure 12. Suspended solids flux measured at the sites listed above in WY 1992.

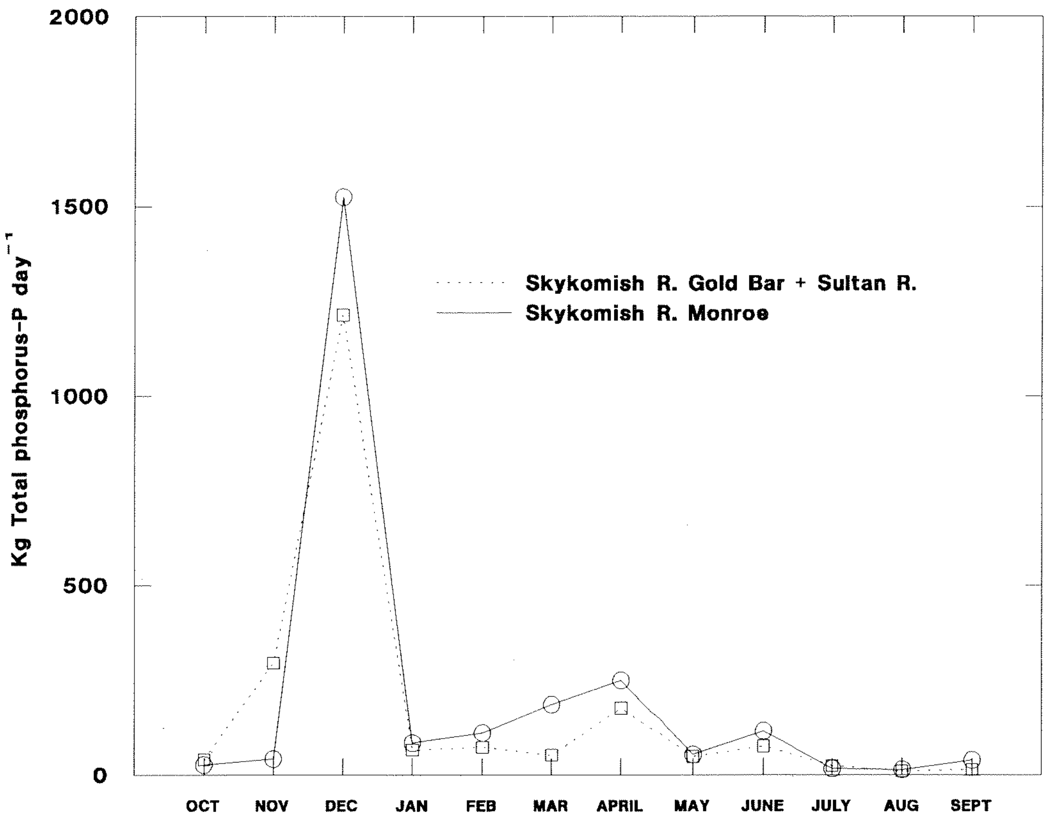

Figure 13. Total phosphorus flux measured at the sites listed above in WY 1992.

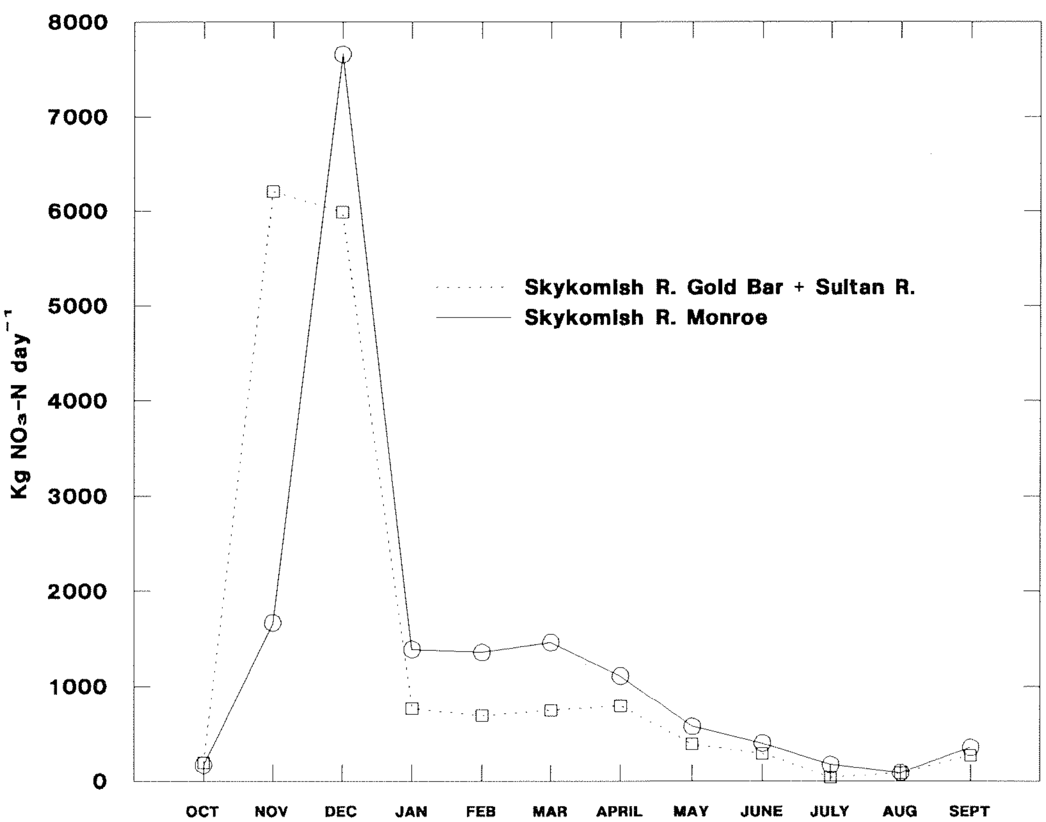

Figure 14. Nitrate-N flux measured at the sites listed above in WY 1992.

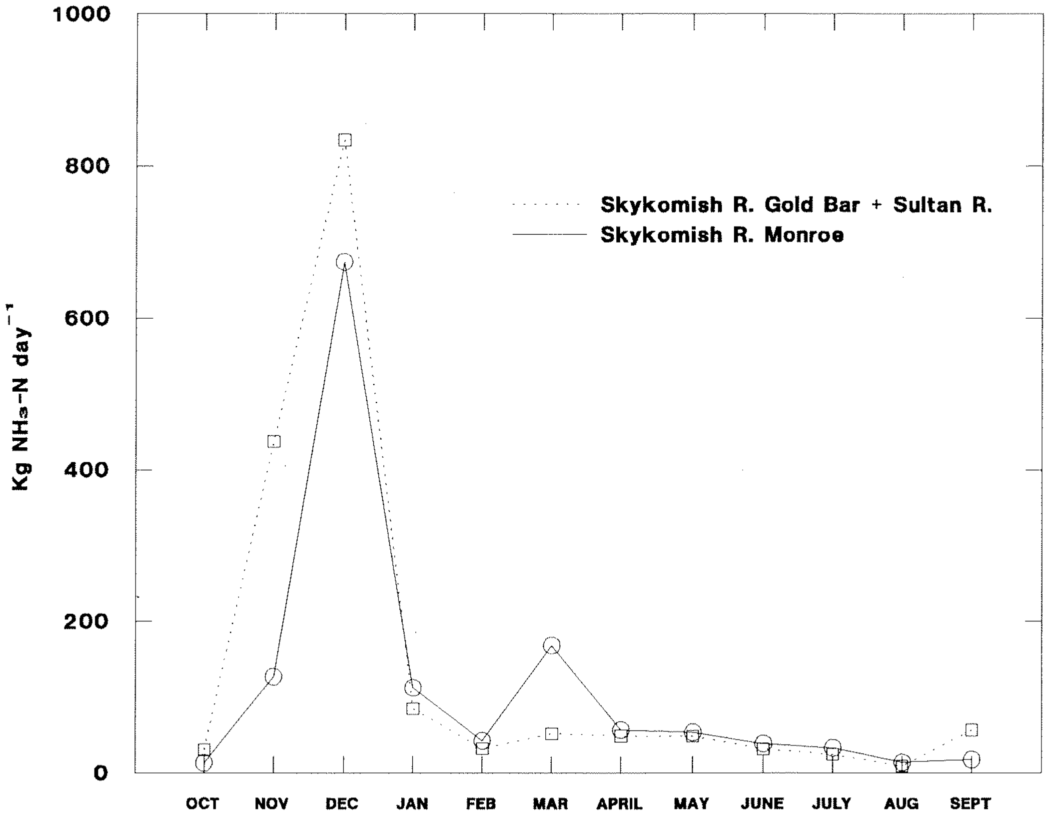

Figure 15. Ammonia-N flux measured at the sites listed above in WY 1992.

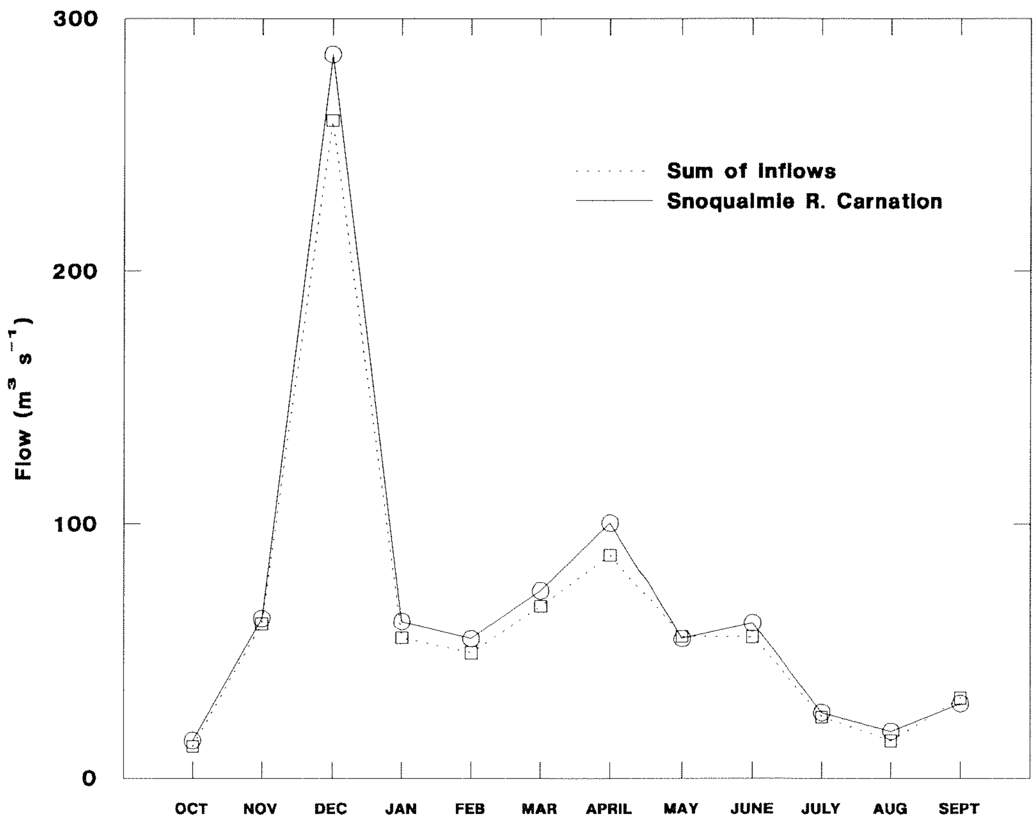

Figure 16. Flow measured at the sites listed above in WY 1992.

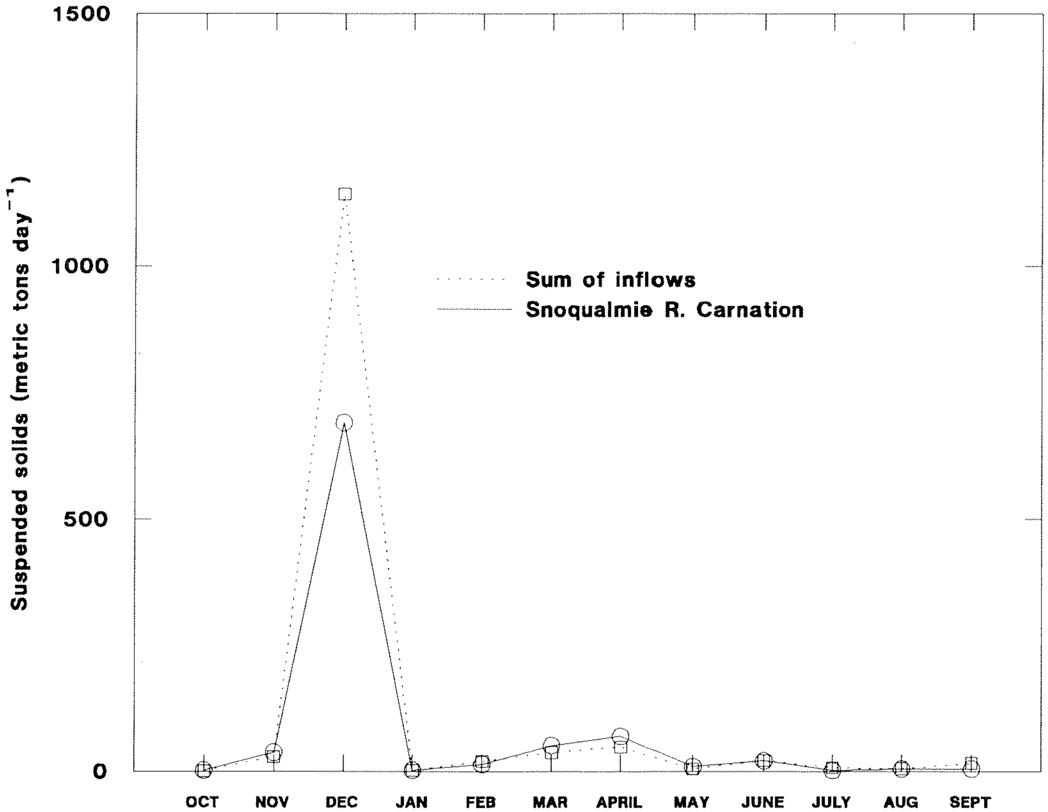

Figure 17. Suspended solids flux measured at the sites listed above in WY 1992.

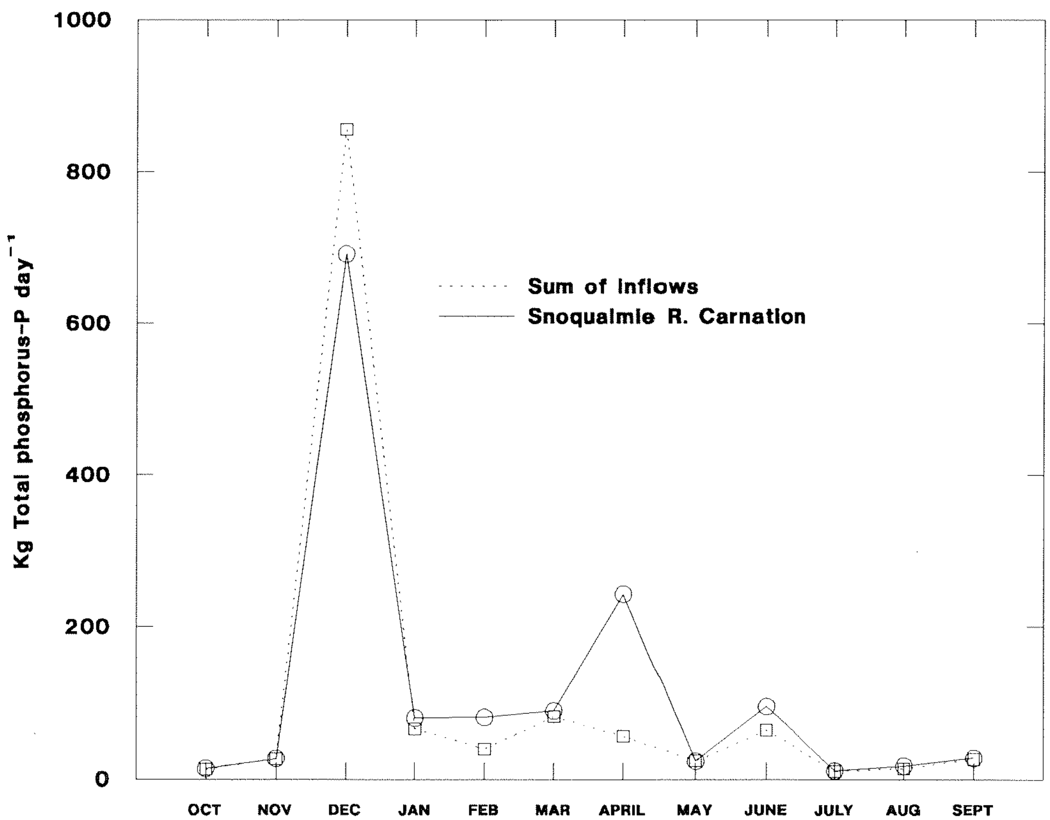

Figure 18. Total phosphorus flux measured at the sites listed above in WY 1992.

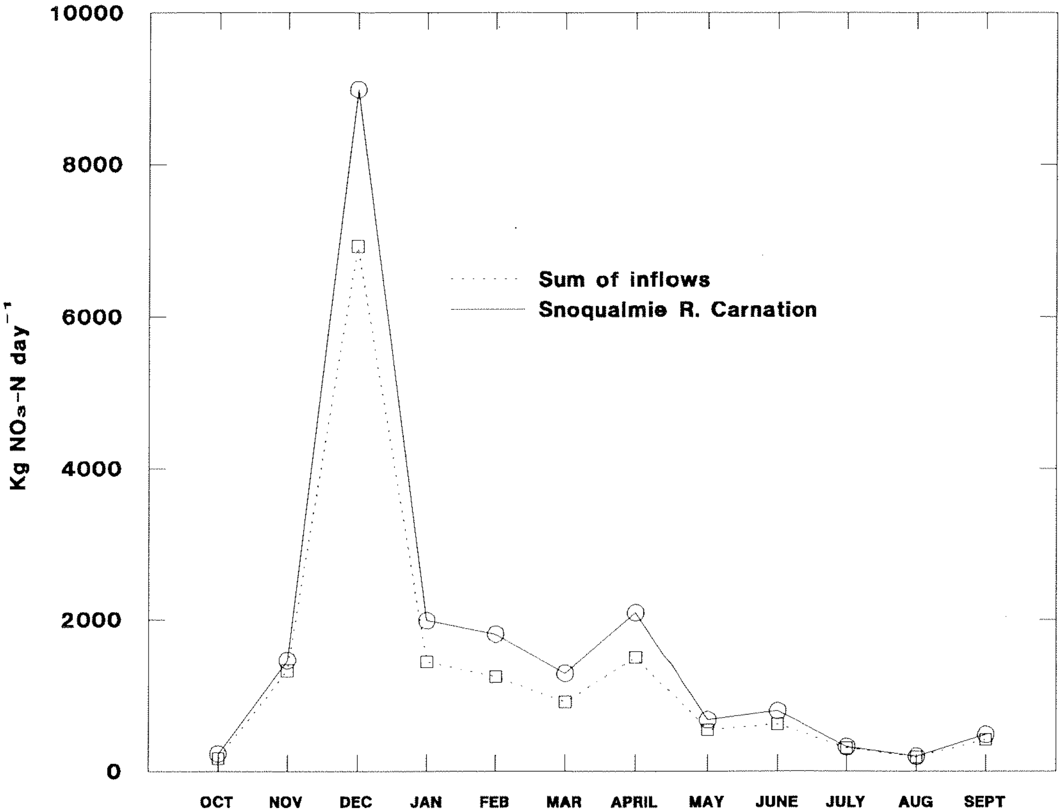

Figure 19. Nitrate-N flux measured at the sites listed above in WY 1992.

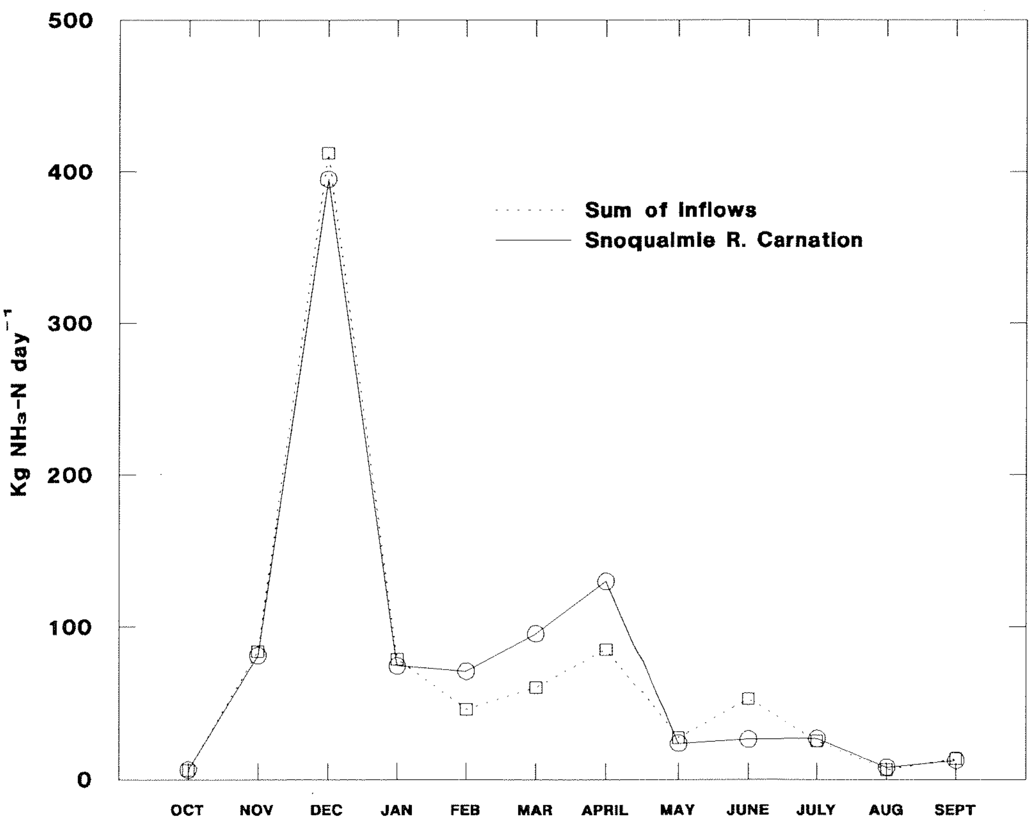

Figure 20. Ammonia-N flux measured at the sites listed above in WY 1992.

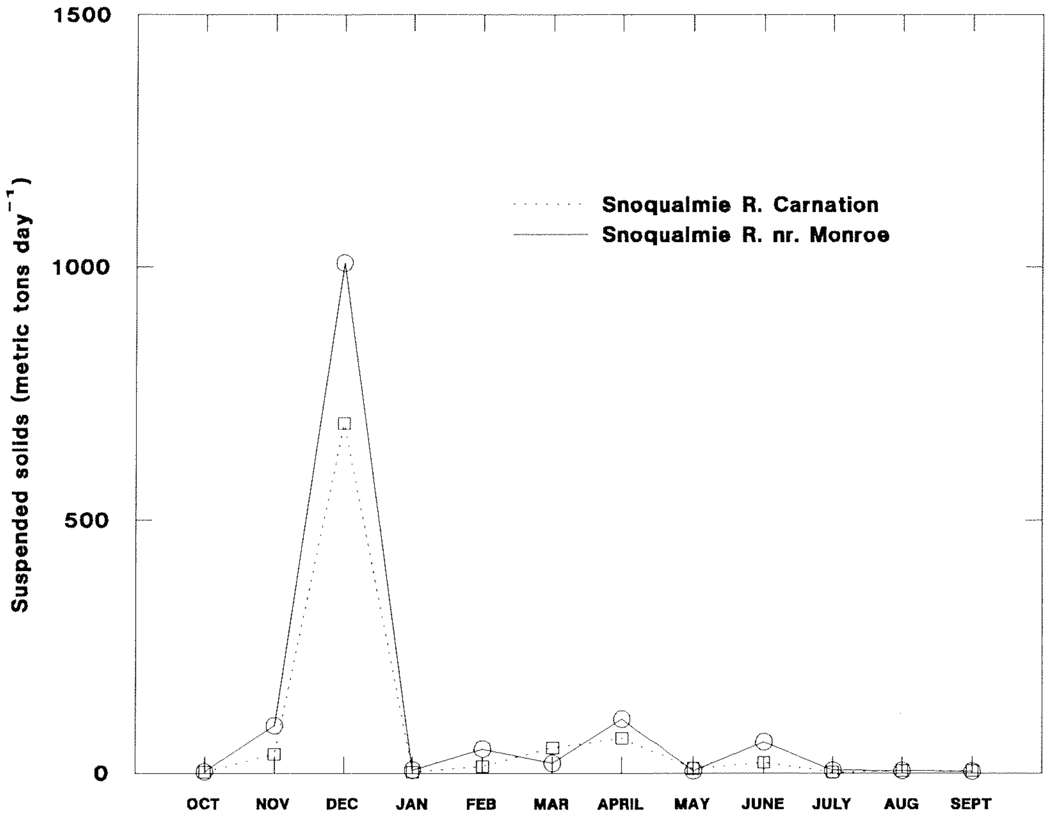

Figure 21. Suspended solids flux measured at the sites listed above in WY 1992.

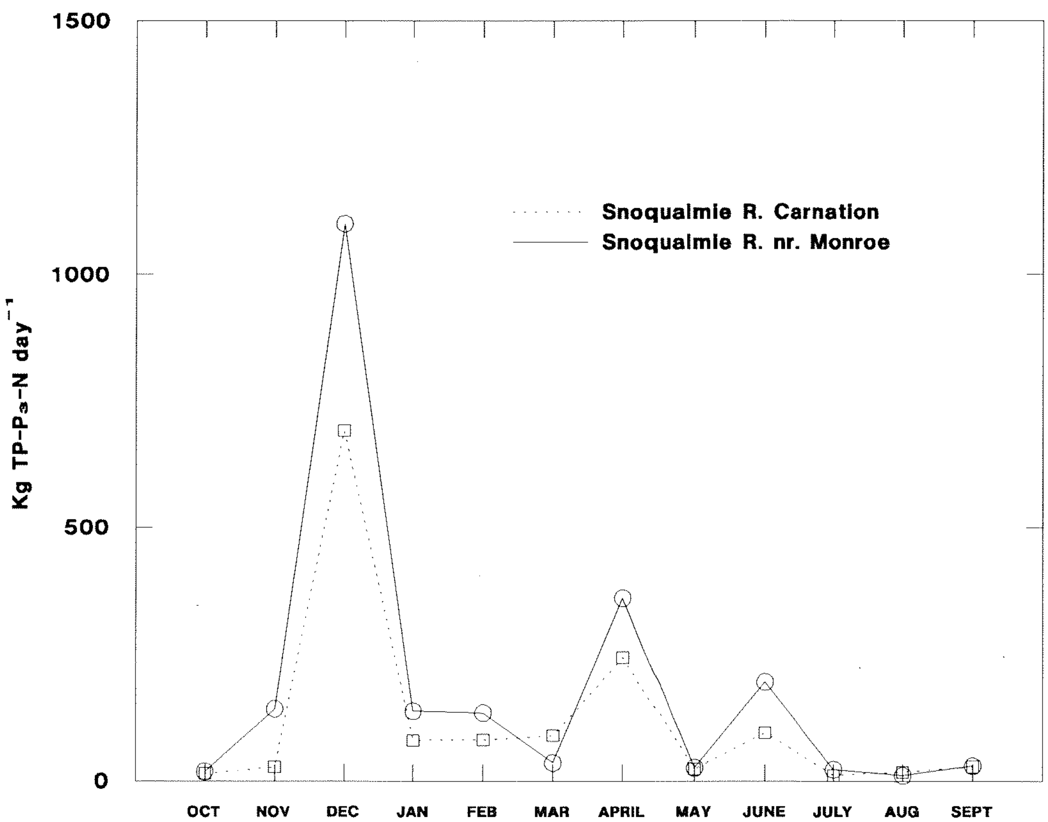

Figure 22. Total phosphorus-P flux measured at the sites listed above in WY 1992.

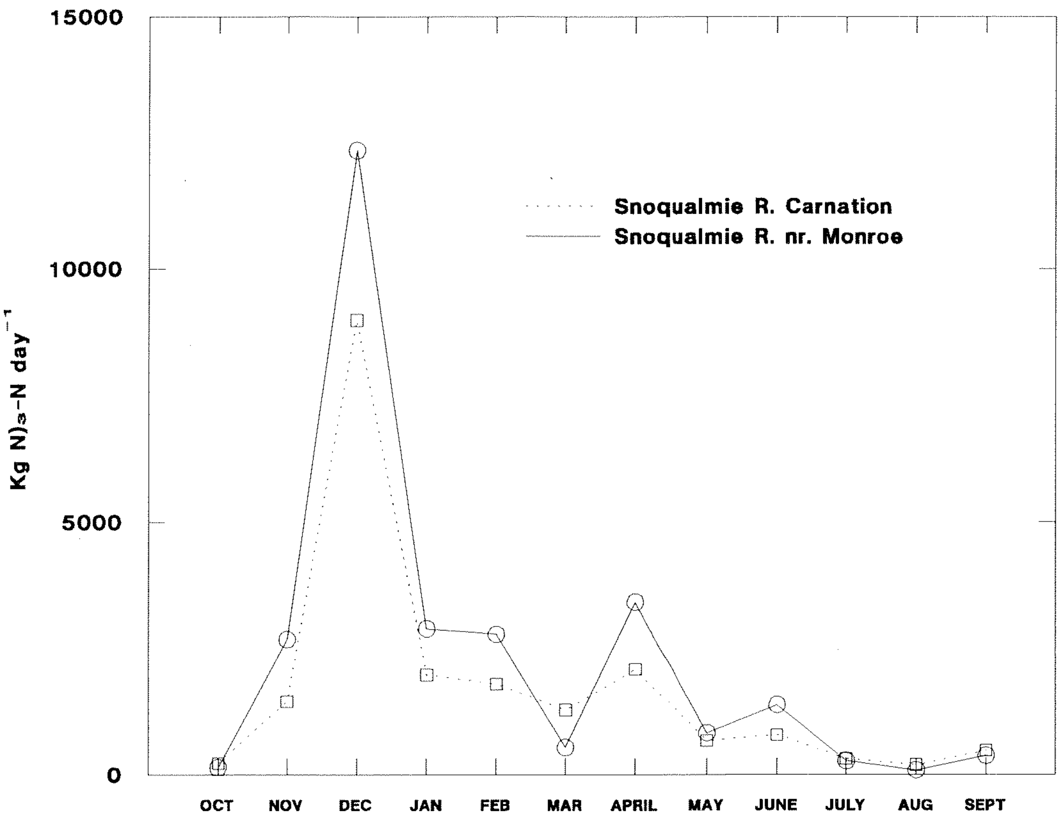

Figure 23. Nitrate-N flux measured at the sites listed above in WY 1992.

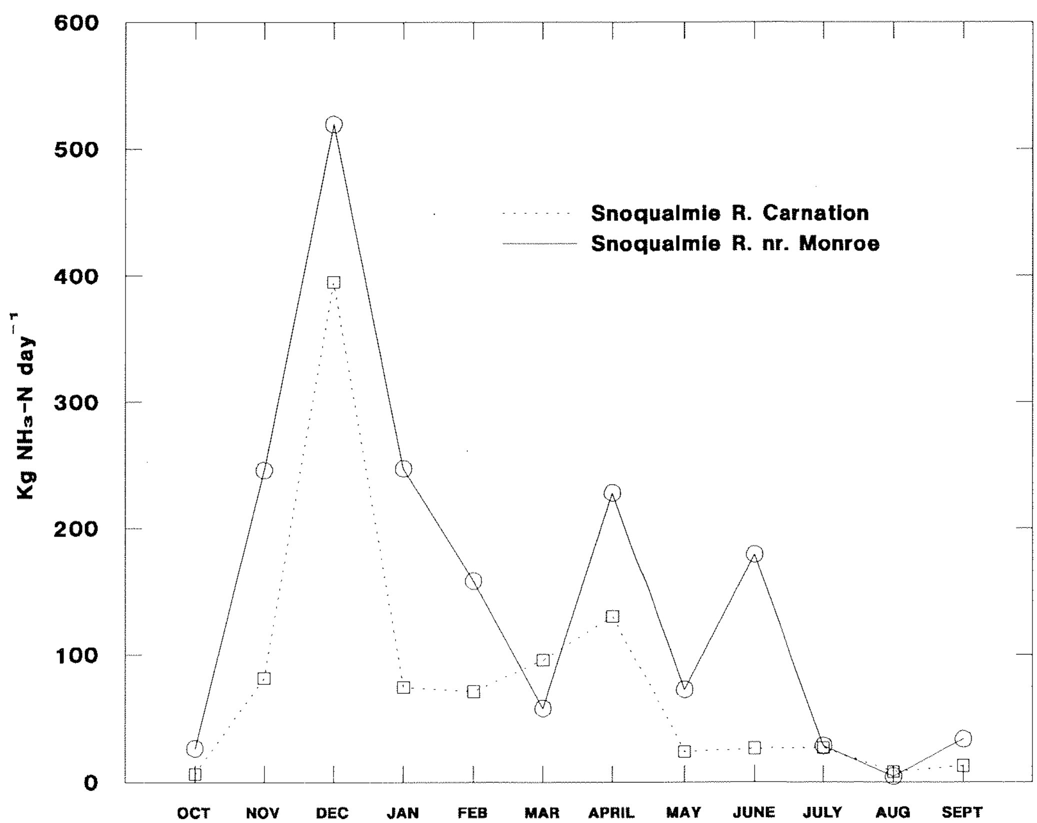

Figure 24. Ammonia-N flux measured at the sites listed above in WY 1992.

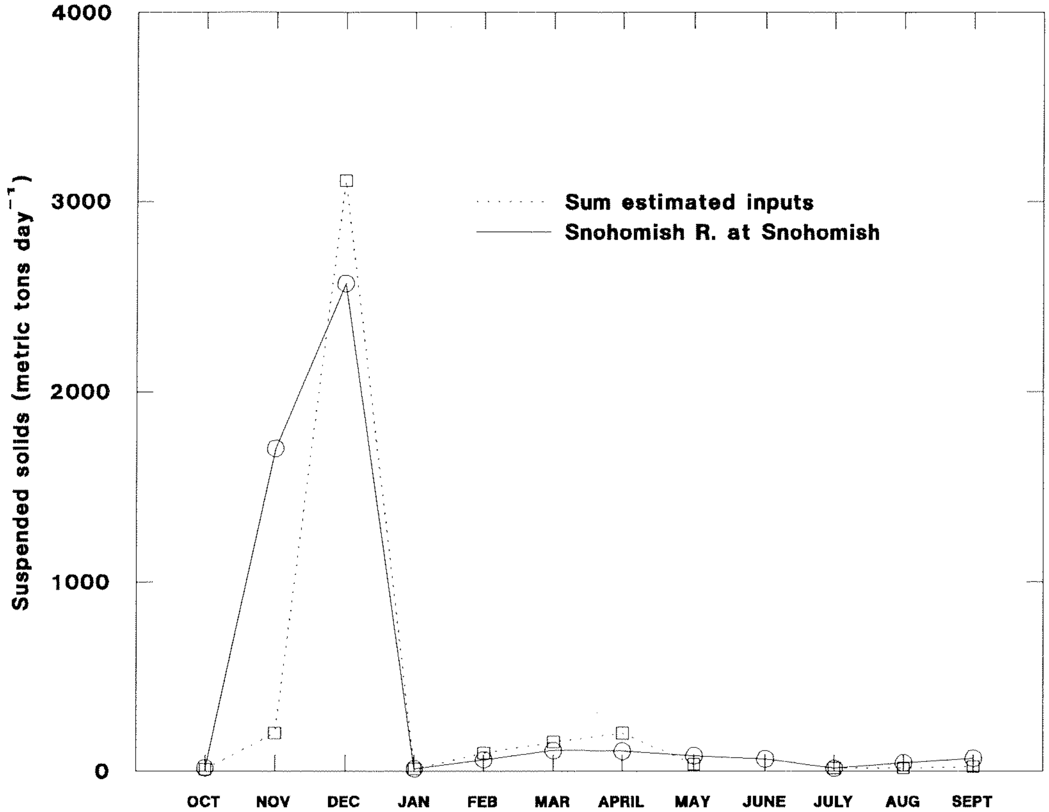

Figure 25. Suspended solids flux measured at the sites listed above in WY 1992.

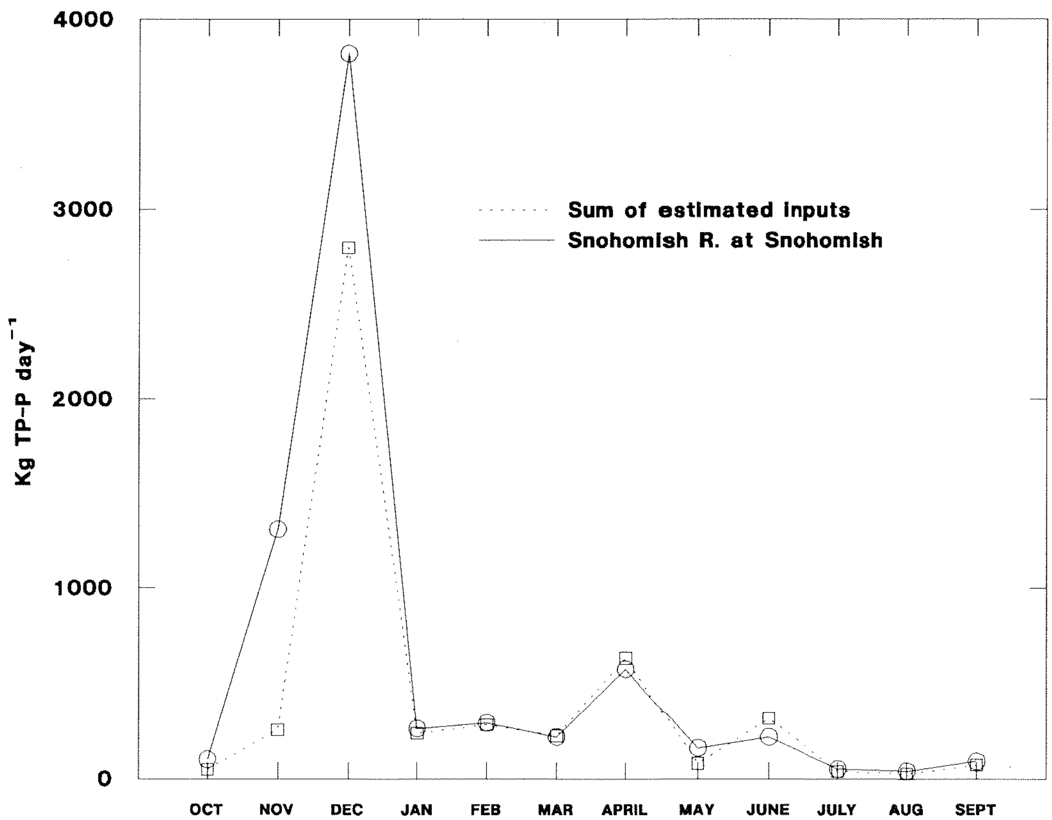

Figure 26. Total phosphorus-P flux measured at the sites listed above in WY 1992.

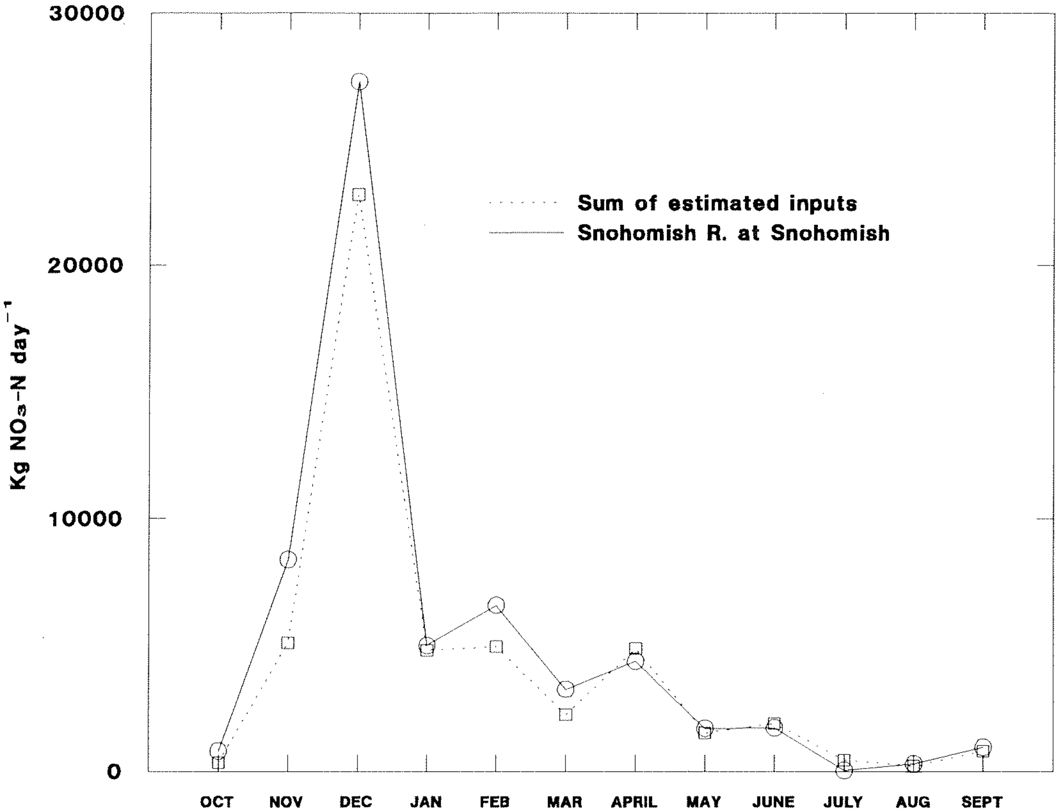

Figure 27. Nitrate-N flux measured at the sites listed above in WY 1992.

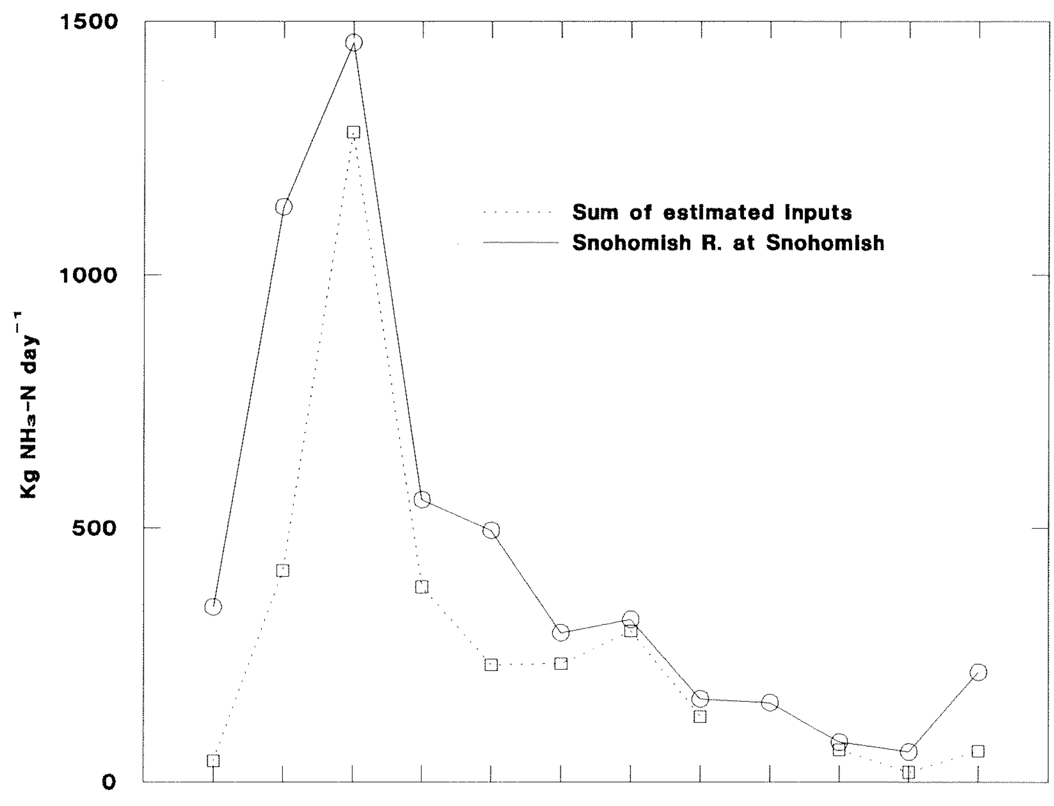

Figure 28. Ammonia-N flux measured at the sites listed above in WY 1992.