Aquatic Ecosystem Sciences LLC

TECHNICAL MEMORANDUM

Upper Klamath Lake Tributary Loading: 2012 Data Summary Report

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INTRODUCTION

The Klamath Tribes have been monitoring nutrient concentration and loading in Upper Klamath Lake (UKL) tributaries since 1991. Data from 1991-1998 were summarized and incorporated into water and nutrient balances for UKL (Kann and Walker 1999). More recently the longer term 1991-2010 database was evaluated for seasonal and inter-annual dynamics, long term trends, and both water and nutrient balances were computed for UKL (Walker et al. 2012). This report serves as an annual update to the UKL tributary water quality database, including a summary of 2012 data (basic summary statistics and graphical analysis), and limited comparison of graphical time-series trends of tributary data collected for the 1991-2012 period. Included in this summary is an update of previous UKL tributary water quality databases with data collected during 2012, including appropriate quality assurance analyses (*see Excel spreadsheets: Klamath Tribes Inflow Nutrient Data 1991-2000.xls* and *Klamath Tribes Inflow Nutrient-Q Data 2001-2012.xls*).

METHODS

Methods followed the Klamath Tribes established procedures for field collection and laboratory analysis of water quality parameters (see Klamath Tribes QAPP and SOP; 2013 for a complete description of these methods). Beginning in 2008 for nutrient parameters, laboratory analyses transitioned from Aquatic Research, INC. in Seattle WA to the Sprague River Water Quality Laboratory (SRWQL) in Chiloquin OR. During the transition period duplicate samples were analyzed by both laboratories to confirm parameter reproducibility. Specific nutrient methodology and field collection protocol are contained in the SRWQL QAPP (Klamath Tribes 2013) and SOP (2013). Nutrient parameters (Table 1) were collected at seven tributary stations during the 2012 sampling season at an approximately biweekly frequency (Table 2; Figure 1; Figure 2). Specific computation of nutrient loads is outlined in Kann and Walker (1999) and Walker et al. (2012), but is briefly summarized here.

Table 1. Nutrient parameters collected in Upper Klamath Lake tributaries, 2012.

Parameter	Abbreviation/Unit	Grab [a]
Total Phosphorus	TP (µg/L)	X
Soluble Reactive Phosphorus	SRP or PO_4 (µg/L)	X
Total Nitrogen	TN (µg/L)	X
Ammonia Nitrogen	NH_4-N (µg/L)	X
Nitrate-Nitrite Nitrogen	NO_3+ NO_2-N (µg/L)	X
Silica	SiO_2 (µg/L)[1]	X

[a] Grab = integrated water column sample and x-sectional sample collected with a Van-Dorn sampler.

[1] Silica measurements were initiated in 2008 and are now included as a regularly measured parameter. The 2012 data report provides the first inclusion of tributary silica data.

Table 2. Station location and Site ID Code for data collected in Upper Klamath Lake tributaries, 2012.

Location	Site ID Code	Latitude/Longitude
Sprague R. @ Kirchers Bridge	WR1000	N42.567806° W121.864472°
Annie Ck @ Snow Park	WR2000	N42.763685° W122.058362°
Wood R @ Weed Rd	WR3000	N42.646461° W121.994959°
Wood R @ Dike Rd	WR4000	N42.581460° W121.941536°
7-mile canal @ Dike Rd	WR5000	N42.581970° W121.970898°
Williamson R @ Bridge on Modoc Pt. Road	WR6000	N42.514355° W121.916714°
Upper Klamath Lake @ Pelican Marina/Fremont Bridge (UKL Outflow)	KL0001/KL0002	N42.238472° W121.805557°

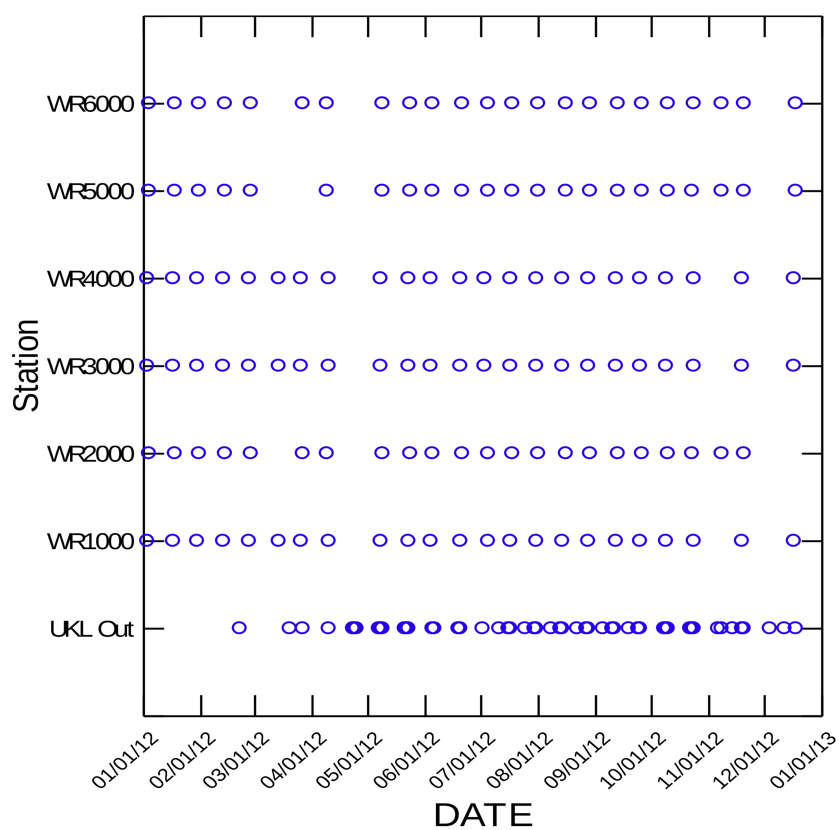

Figure 1. Spatial-temporal sampling matrix for Upper Klamath Lake tributaries, 2012.

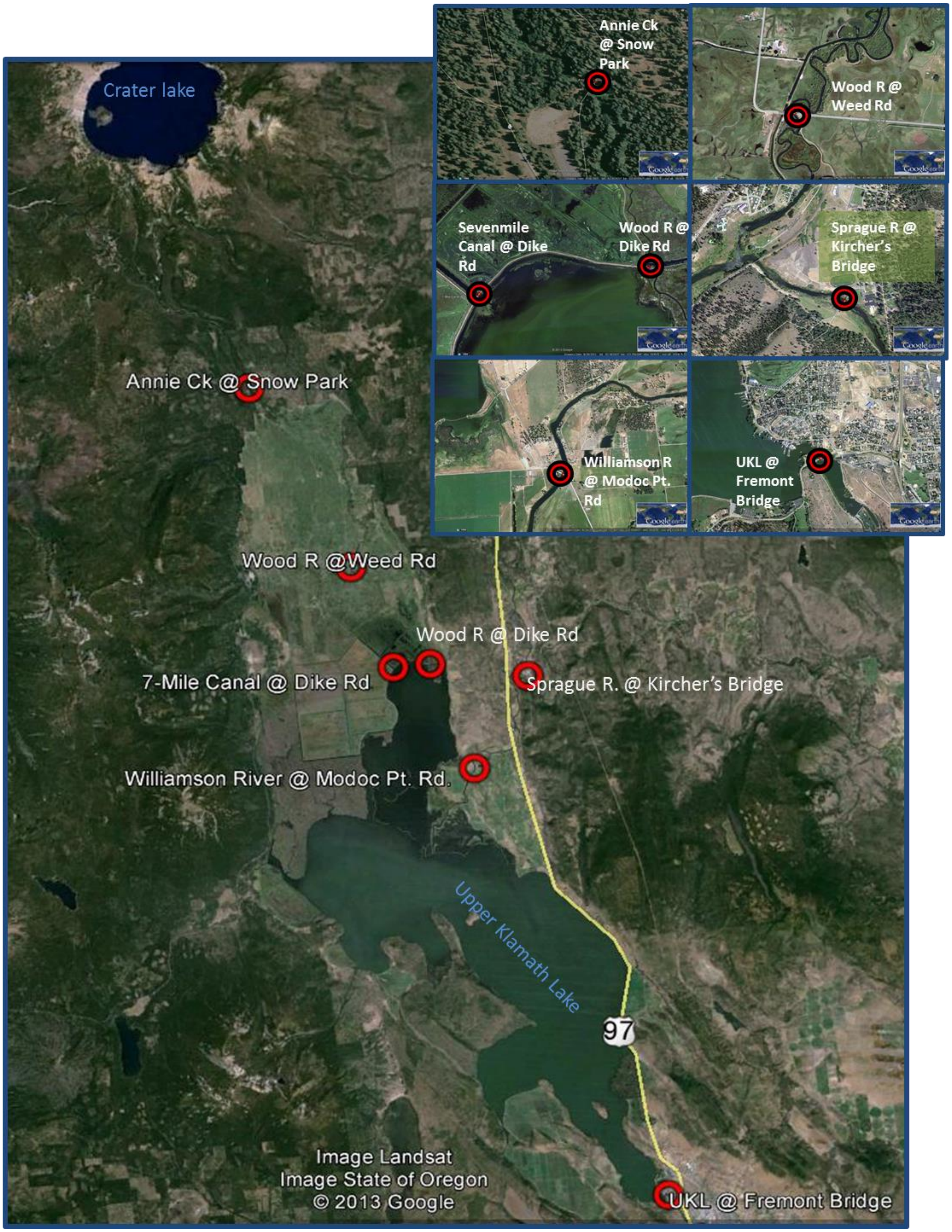

Figure 2. Location of Klamath Tribes Upper Klamath Lake tributary sampling stations.

Daily inflow volume for the Williamson and Sprague Rivers on a given sample date was extracted from continuous daily discharge data obtained from U.S. Geological Survey (USGS) stream-flow discharge stations. These data were obtained online– Williamson River Gage 11502500:http://waterdata.usgs.gov/nwis/dv/?site_no=11502500&agency_cd=USGS&referred_module=sw, and Sprague River Gage 11501000:
http://waterdata.usgs.gov/or/nwis/dv/?site_no=11501000&agency_cd=USGS&referred_module=sw).
Daily outflow volume for Upper Klamath Lake (UKL outflow) was computed from the sum of USGS discharge station at Link River 11507500:
http://waterdata.usgs.gov/or/nwis/dv/?site_no=11507500&agency_cd=USGS&referred_module=sw,
and USBR A-Canal daily discharge measurements:
http://www.usbr.gov/mp/kbao/operations/water/korep1.cfm?lakeid=ukldata3.

For the Wood R. @ Weed and Wood R. @ Dike stations, continuous daily discharge measurements were generated by Graham Matthews and Associates (e.g., see GMA 2004) for 1992-2006, but these data were not available after 2006 for Dike Road. However, instantaneous discharge continued to be measured at Wood R. @ Weed, Wood R. @ Dike, 7-mile canal @ Dike Rd and Annie Cr. @ Snow Park stations by both the Klamath Tribes and GMA (2004a; 2011a). Flow measurements coinciding with nutrient sample collection dates are shown in Figure 3. Although additional nutrient concentration data were collected by GMA (e.g., 2004b; 2011b) and these data were incorporated into tributary loading calculations for the overall 1991-2010 analysis (Walker et al. 2012), only data collected by the Klamath Tribes are presented in this annual data update report.

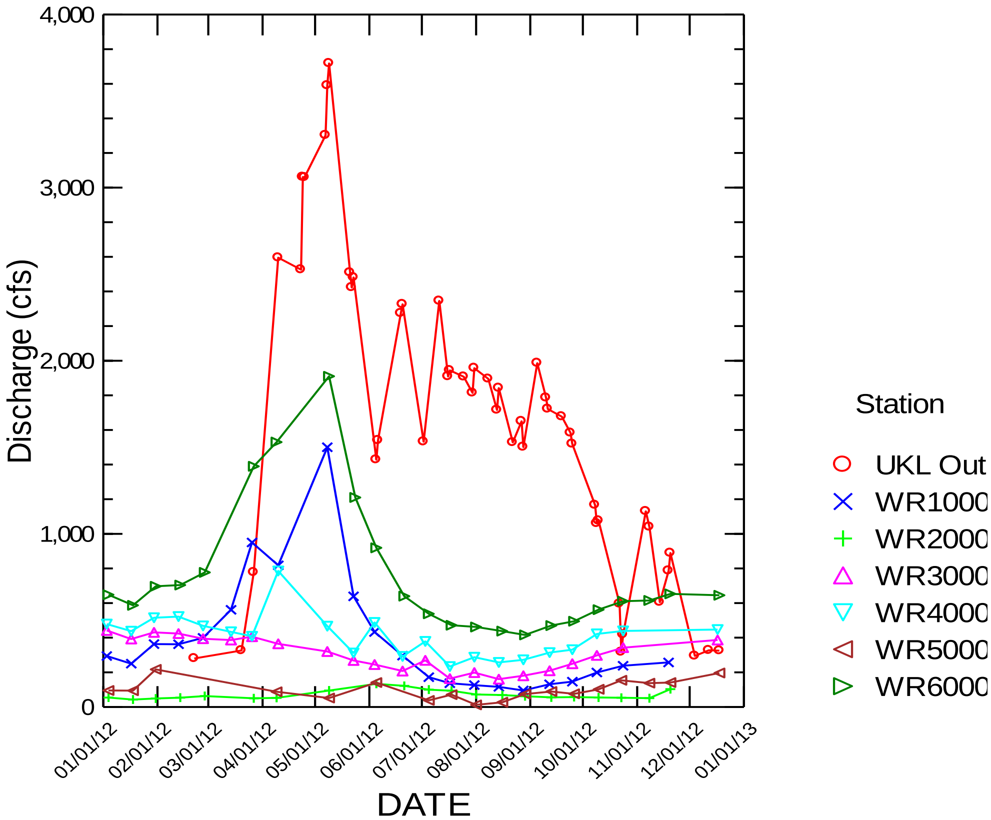

Figure 3. Flow (cfs) measurements coinciding with nutrient sample collection dates, 2012. Flow shown only for dates that nutrient data exist.

The total phosphorus (TP) and total nitrogen (TN) mass (kg/day) for each 2012 sample station and date were computed as the product of daily water volume and measured TP or TN concentration. Nutrient data collection at the UKL outflow station (Upper Klamath Lake @ Fremont Bridge) was discontinued by the Klamath Tribes during 2006-2011 due to funding reductions. Although the UKL sampling station PM is used as a surrogate for the UKL outflow for intervals when data for Upper Klamath Lake @ Fremont Bridge are not available, this caused data gaps for the October-March period during 2006 and 2007.

Beginning in 2008, the U.S. Bureau of Reclamation (USBOR) began monitoring nutrients during the winter months at Link River Dam and near the mouth of the Link River. These data were provided by USBOR along with limited data collected by PacifiCorp during the winter of 2009 and 2010 (Excel spreadsheets: *KRWQ2007-2010KLLD.xls* and *Pacificorpdata2009-2010.xlsx*). Outflow provided by USBOR for 2011 and 2012 also included additional data for 2009 and 2010 that had not been previously provided (Excel spreadsheets: *KRWQ2007-2012KLLD.xls*[2]) In addition, the Klamath Tribes again began sampling Upper Klamath Lake @ Fremont Bridge in 2012. Station names for the various outflow stations were standardized by renaming them UKL-Out. When stations were sampled on the same date a mean was taken. Loading graphs and summaries are computed based on the October-September hydrologic water year (denoted HY in below plots).

RESULTS/DISCUSSION

Nutrient Concentration

The 2012 nutrient concentration pattern among inflow stations was similar to that of the 1991-2011 sampling period (Figure 4); total P and PO_4-P tended to be slightly higher at the Wood River and Seven Mile stations (WR3000, WR4000, and WR5000); total N tended to be lower for the Wood River stations (WR3000 and WR4000) but higher for Seven Mile (WR5000); values for the Williamson River (WR6000) tended to be intermediate relative to other stations for most parameters, but values for the Sprague River (WR1000) tended to be lower for TP and PO_4-P, and second highest for TN after Seven Mile. In addition, Annie Creek at Snow Park (previously sampled from 2003-2011) showed consistently lower concentrations for all nutrient parameters except nitrate/nitrite among the inflow stations (Figure 4; Table 3).

With the exception of Seven Mile Canal, the UKL outlet (KL0001) tended to be higher than inflow stations for TP, lower for PO_4, and substantially higher for TN and ammonia (NH_4-N). Upper quartile values for NO_3-N were also higher at the UKL Outlet station than for inflow

[2] sources: http://www.kbmp.net/collaboration/klamath-hydroelectric-settlement-agreement-monitoring, and spreadsheet "UKL-FreemontBridge-WQ-2012-13-BOR.xlsx" provided by Rick Carlson, Physical Scientist, Bureau of Reclamation Klamath Basin Area Office, racarlson@usbr.gov. The latter file includes additional data collected at Fremont Bridge as part of a 3-year nutrient budget study of the Klamath Project.

stations. Outflow NO_3-N was notably higher than inflow stations during 2012. Similar to 2010, NH_4-N at the UKL Outlet was substantially higher than Seven Mile Canal[3] (Figure 4; Table 3).

Although in 2012 the inter-quartile range for TP concentration was somewhat higher at Annie Creek and the Wood River at Weed Rd., remaining stations were similar to the long-term 1991-2011 distribution, with fewer extreme values as well (Figure 4). Similar to 2011, the 2012 distribution of Sprague River PO_4-P concentration was noticeably lower when compared to the long-term distribution. Although other inflow stations were similar to their respective long-term PO_4-P distributions, as with TP there were fewer extreme values. The UKL-Outflow PO_4-P distribution in 2012 was noticeably higher than the long-term distribution. Other notable departures from the long-term distributions include overall lower Outflow, Annie Cr., Wood-Dike, and Williamson TN, higher Annie Cr., Wood-Weed, Wood-Dike, and Williamson NH_4-N, and higher Outflow and Williamson NO_3-N (Figure 4). Comparisons of inflow ammonia and nitrate-nitrite between 2012 and the long-term distribution are confounded by levels near method detection limits and by a change in detection limits when the SRWQL began processing samples in 2008[4]. However, Outflow, Williamson River, and Sevenmile values for these parameters are affected to a lesser degree because values tend to be above method detection limits. Higher Outflow nitrate values in 2012 may be due to the increased sampling frequency during winter months when NO_3-N is usually higher overall than other seasons.

Similar to 2011, time series plots of the 2012 concentration data show Seven Mile Canal (WR5000) to have among the highest values for TP, PO_4, PP (particulate P which equals TP minus PO_4), and TN (Figure 5). Phosphorus values tend to seasonally peak during both the spring runoff period and the summer irrigation season. With respect to PO_4, the Wood River stations also showed high values, followed by the Williamson and then the Sprague River; a pattern similar to 2011. However, for PP, Sprague River concentrations were often among the highest in the spring, but declined during the low-flow summer period (Figure 5). TP, PO_4, PP, and TN at the UKL Outflow station increased relative to the inflow stations during the summer algal growing season (primarily July-August).

Ammonia (NH_4-N) and nitrate (NO_3-N) at the Outflow station also increased seasonally, ammonia in July and nitrate in August, with values tending to remain high through the fall and winter before declining in the spring (Figure 6). In general, ammonia in Sevenmile Cr. tends to be among the highest relative to other inflow stations. Silica concentration at the Wood River and Annie Cr. Stations tended to be higher than the Sevenmile, Sprague, and Williamson stations during the spring, but were more similar during the early summer months before diverging again during the later summer and fall (Figure 6). The UKL Outflow station showed a clear seasonal pattern where values were depressed during the spring and early summer before increasing sharply in July to levels higher than the various inflow stations (Figure 6). The spring silica depression at the Outflow station coincides with diatom blooms occurring in Upper Klamath Lake.

[3] During 2011 and 2009 the UKL Outlet was similar to Seven Mile Canal (Kann 2011)
[4] Aquatic Research Inc. indicated a reporting limit of 10 µg/L; the SRWQL utilizes a reporting limit of 12 µg/L.

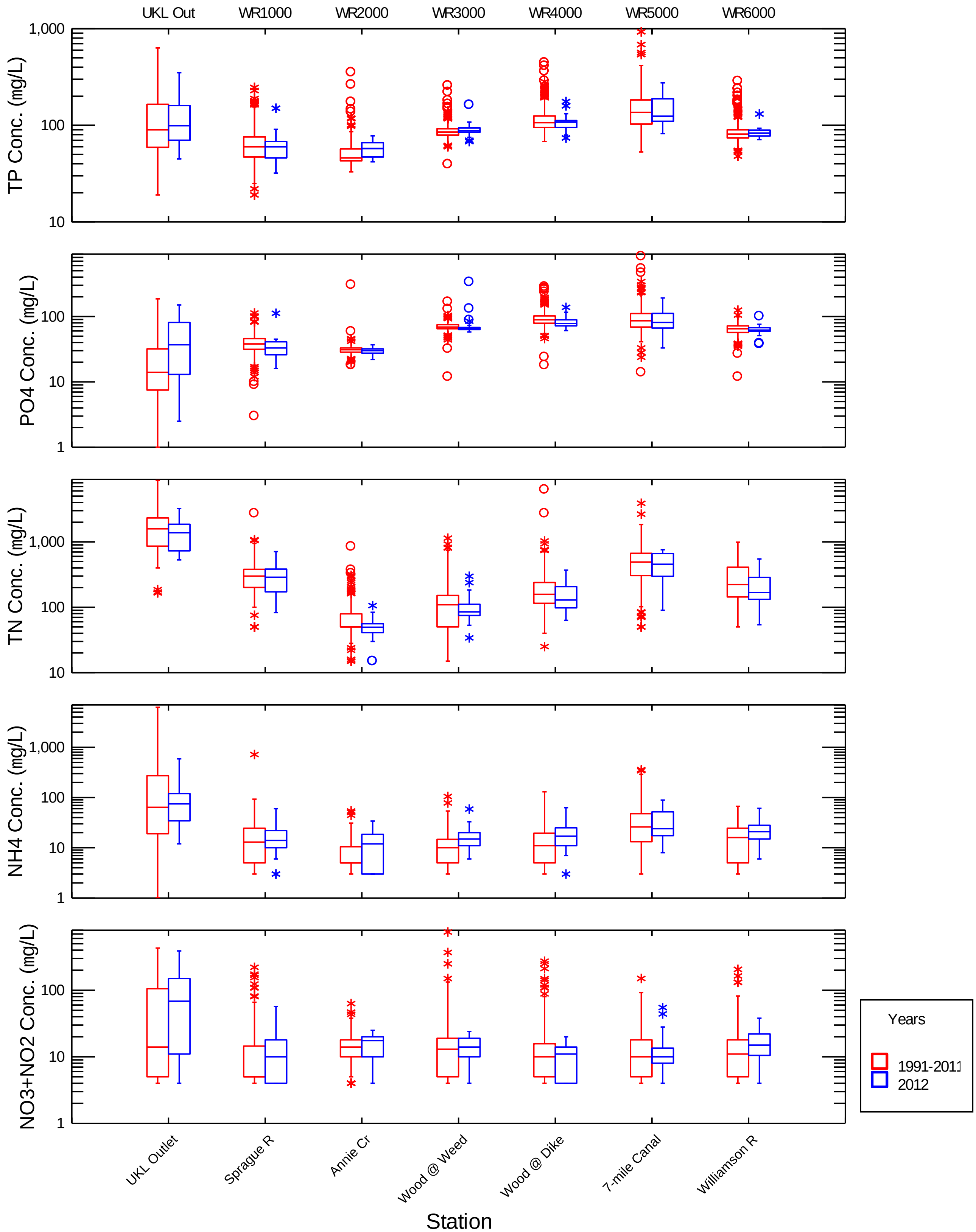

Figure 4. Station distributions of TP, SRP, TN, NH4-N, and NO3+ NO2-N concentration (µg/L) compared between 1991-2011 (red) and 2012(blue).

Table 3. Basic statistics by station for TP, SRP, TN, NH_4-N, NO_3+ NO_2-N and SiO_2 concentration, and TP and TN load, Water Year 2012.

Station Code	Station Name	Parameter	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	Silica (µg/L)	Total Phosphorus Load (kg/d)	Total Nitrogen Load (kg/d)
UKL Out	UKL Outlet	N of Cases	42	26	42	35	30	12	42	42
UKL Out	UKL Outlet	Median	99	37	1380	75	69	21150	449	4991
UKL Out	UKL Outlet	Arithmetic Mean	130	50	1476	105	105	27150	556	6113
UKL Out	UKL Outlet	Pct25	70	13	730	33	11	16000	328	3142
UKL Out	UKL Outlet	Pct75	160	81	1860	120	150	41250	637	6864
WR1000	Sprague R	N of Cases	25	25	25	25	25	19	24	24
WR1000	Sprague R	Median	60	33	288	14	10	27600	38	125
WR1000	Sprague R	Arithmetic Mean	62	35	292	17	16	28268	63	334
WR1000	Sprague R	Pct25	46	25	172	10	4	25525	14	98
WR1000	Sprague R	Pct75	69	42	383	22	20	30400	82	394
WR2000	Annie Cr	N of Cases	24	24	24	24	24	18	23	23
WR2000	Annie Cr	Median	58	30	50	12	18	38150	10	7
WR2000	Annie Cr	Arithmetic Mean	58	30	50	13	15	37717	10	9
WR2000	Annie Cr	Pct25	47	28	41	3	10	35600	7	6
WR2000	Annie Cr	Pct75	66	32	56	19	20	41300	11	8
WR3000	Wood @ Weed	N of Cases	25	25	25	25	25	19	25	25
WR3000	Wood @ Weed	Median	88	66	85	15	14	37700	80	72
WR3000	Wood @ Weed	Arithmetic Mean	91	80	106	17	14	37037	72	76
WR3000	Wood @ Weed	Pct25	85	63	74	11	10	35350	49	54
WR3000	Wood @ Weed	Pct75	94	69	112	21	19	38575	93	92
WR4000	Wood @ Dike	N of Cases	25	25	25	25	25	19	25	25
WR4000	Wood @ Dike	Median	108	78	129	17	11	36600	105	128
WR4000	Wood @ Dike	Arithmetic Mean	109	83	158	20	11	36553	111	156
WR4000	Wood @ Dike	Pct25	95	72	97	11	4	33525	80	100
WR4000	Wood @ Dike	Pct75	113	89	207	26	14	38325	123	164
WR5000	7-mile Canal	N of Cases	23	23	23	23	23	17	22	22
WR5000	7-mile Canal	Median	124	81	455	24	10	30800	19	50
WR5000	7-mile Canal	Arithmetic Mean	148	94	460	36	14	30247	22	70
WR5000	7-mile Canal	Pct25	109	66	282	17	8	28125	7	20
WR5000	7-mile Canal	Pct75	190	113	669	53	14	32325	34	125
WR6000	Williamson R	N of Cases	24	24	24	24	24	18	23	23
WR6000	Williamson R	Median	83	62	168	21	15	32900	129	210
WR6000	Williamson R	Arithmetic Mean	84	62	224	24	17	31917	156	531
WR6000	Williamson R	Pct25	78	59	132	15	11	31100	99	188
WR6000	Williamson R	Pct75	89	68	287	28	22	34600	176	495

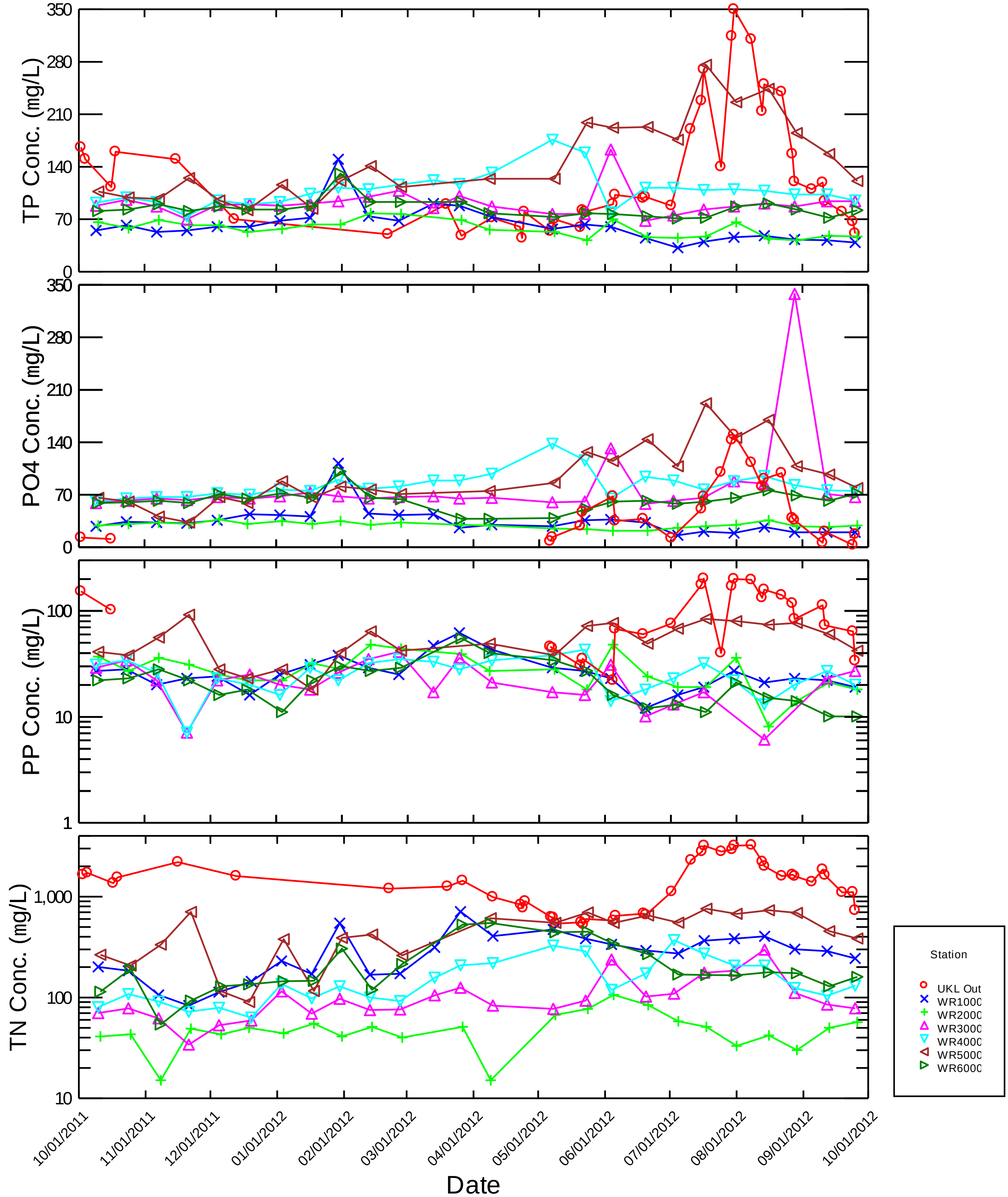

Figure 5. Time-series plot of TP, SRP, PP and TN, NH_4-N, NO_3+ NO_2-N and SiO_2 concentrations for Upper Klamath Lake tributaries and outflow, HY 2012.

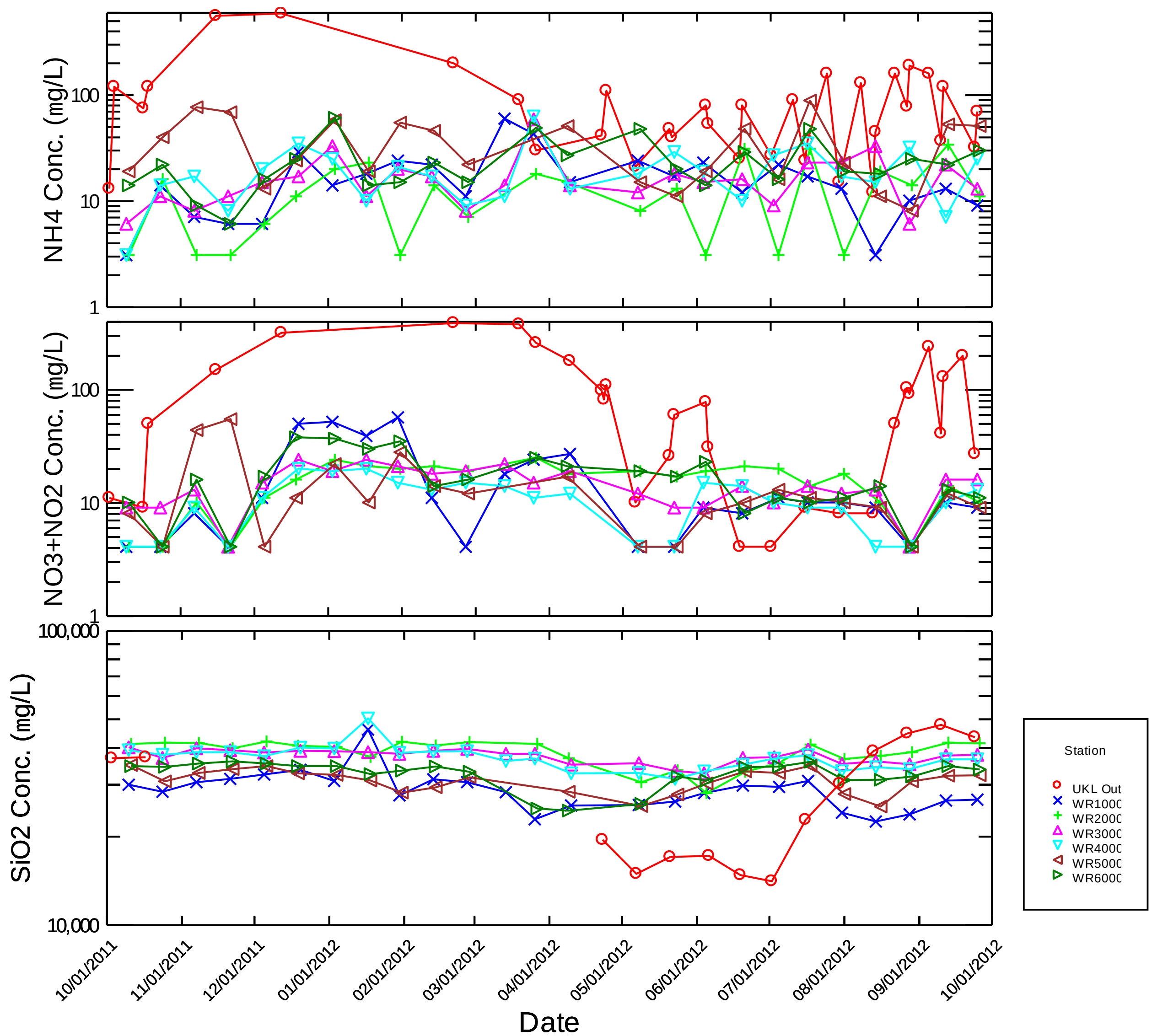

Figure 6. Time-series plot of NH_4-N, NO_3+ NO_2-N and SiO_2 concentrations for Upper Klamath Lake tributaries and outflow, HY 2012.

The TN:TP ratio at the UKL Outflow station was relatively high (TN:TP > ~15) during the late fall and early winter (2011-2012), and similar to earlier years (see Kann 2011) ratios remained higher than tributary stations through the season (Figure 7). The lowest values of the year (~5) occurred during late-May and June. The overall pattern appears similar to earlier years when the TN:TP ratio at UKL Outflow was higher (TN:TP ≅ 10) than tributary stations in April, declined during May and June, increased during early summer UKL bloom development, and declined through the bloom decline period before increasing again in September (Figure 7). The TIN:SRP ratio in the Outflow decreased from ~50 during April to seasonal low values in late-July and early-August (~0.2), before increasing sharply into October (~20) (Figure 7). Both TN:TP and the majority of TIN:SRP values in the inflow tributary stations indicate nitrogen limiting conditions (<10 for TN:TP and <1 for TIN:SRP) that would tend to promote nitrogen-fixing algae such as the *Aphanizomenon* prevalent in UKL. The Wood River in particular showed very low TIN:SRP ratios (<0.3).

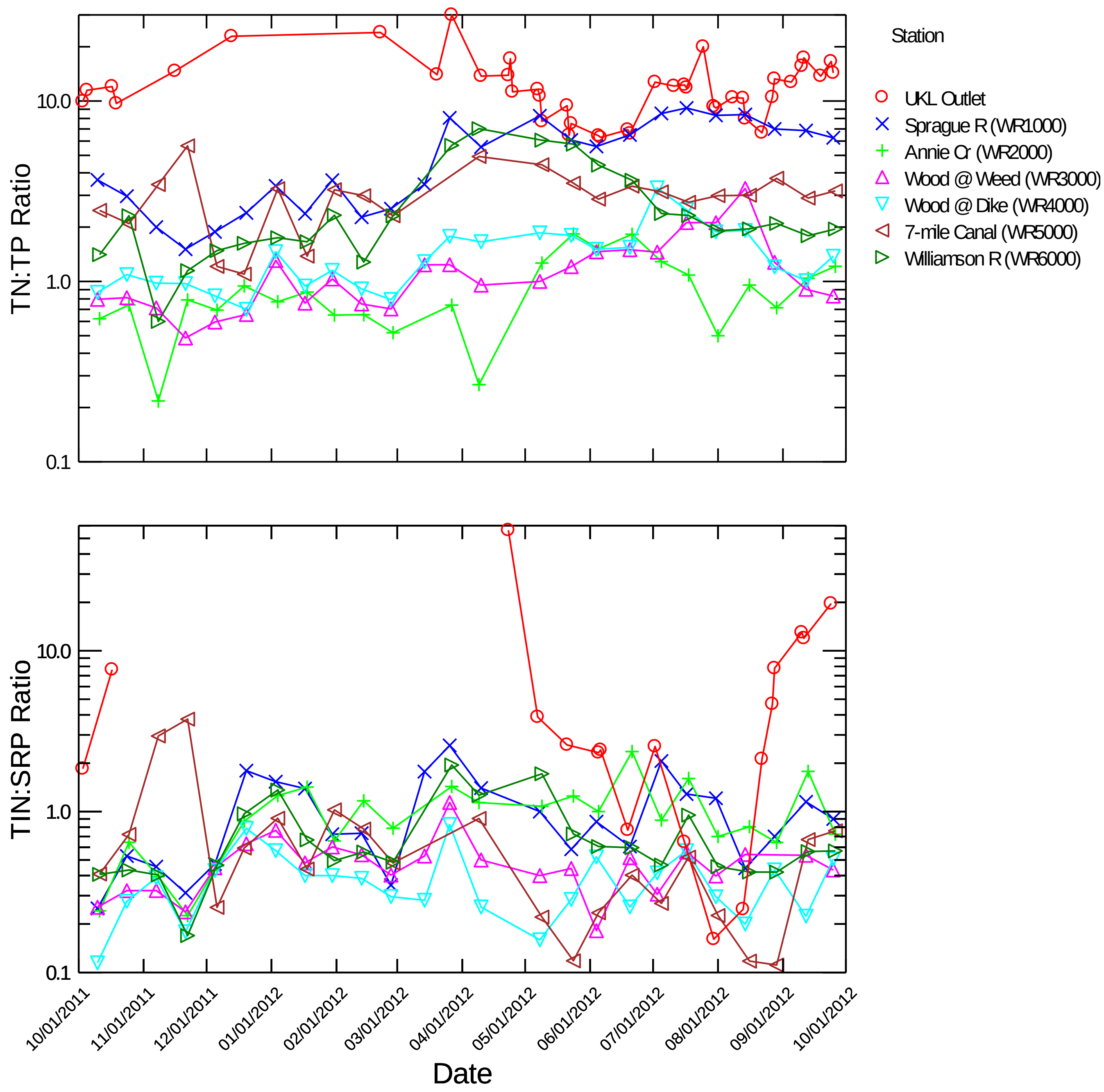

Figure 7. Total nitrogen to total phosphorus (TN:TP) and total inorganic nitrogen (NOx-N+NH_4-N) to PO_4 (TIN:SRP) ratios in Upper Klamath Lake tributaries and outflow stations, HY 2012.

Time-series plots of these ratio data comparing the Williamson River and UKL Outflow (summarized for the April-October period when data for both stations were consistently available) show that both ratios (TP:TN and TIN:SRP) were always higher leaving UKL than they were in the Williamson River inflow (Figure 8). Much of this increase is likely due to increases in UKL nitrogen due to both nitrogen-fixation by blue-green algae (particularly the dominant *Aphanizomenon flos-aquae*) and sediment regeneration of ammonia to the water column (although the ultimate source of the sediment nitrogen is also derived from settled algal biomass). Ratios rose in the outflow relative to inflow despite additional internal loading or sediment recycling of phosphorus (Walker et al. 2012), which would tend to drive ratios downward. There is also indication of cyclical sub-decadal trends, particularly for the TIN:SRP ratio, over the 1991-2012 period. Further analysis is required to explore these apparent trends.

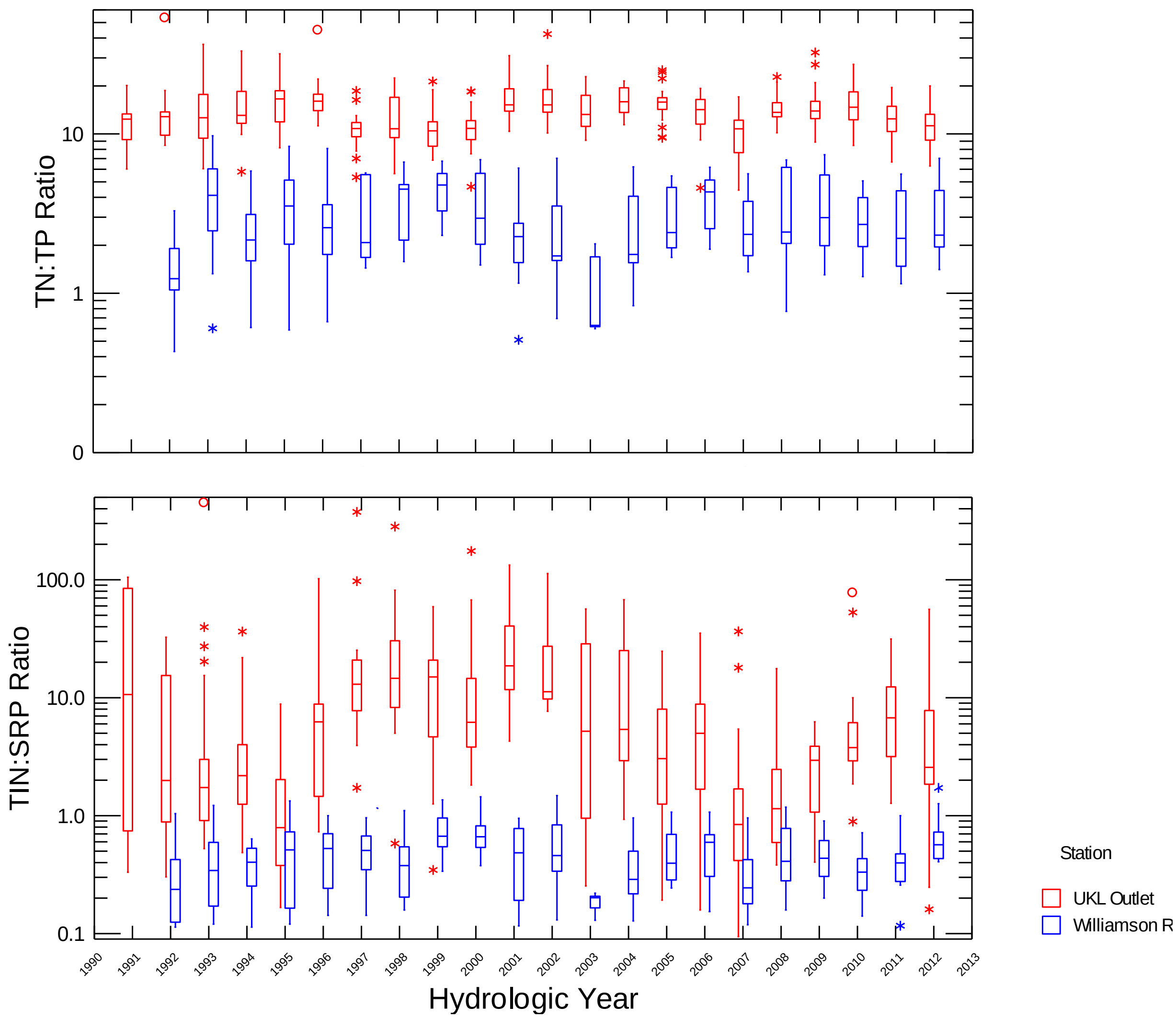

Figure 8. Total nitrogen to total phosphorus (TN:TP) and total inorganic nitrogen (NOx-N+NH_4-N) to PO_4 (TIN:SRP) ratios in the Williamson River and UKL outflow stations, April-October: 1991-2012.

TP and TN Loading

2012 Seasonal Pattern

The 2012 seasonal TP and TN tributary loading pattern showed a peak during the April-May period, generally coinciding with peak discharge (Figure 3; Figure 9). Loads then declined during the early-spring to early-summer period, generally remaining stable through the remainder of the season. An initial increase in UKL outflow loads of both TP and TN began in late-March, with a secondary and larger increase in early-July that is tied to internal nutrient recycling from sediments and nitrogen fixation in UKL (e.g., see Kann 1998; Kann and Walker 1999; Walker et al. 2012). The 2012 increase in Outflow TP and TN loading occurred earlier than in 2011 when the initiation of the algal bloom was delayed by about a month (Kann 2012), but was still somewhat later than earlier years when the increase occurred in June. Outflow TP loads were similar to or lower than Williamson River and Sprague River loading during the late-winter to early-spring spring period, but were then higher through the remainder of the year, while outflow TN loads generally remained higher than those for the Williamson River over this same period (Figure 9).

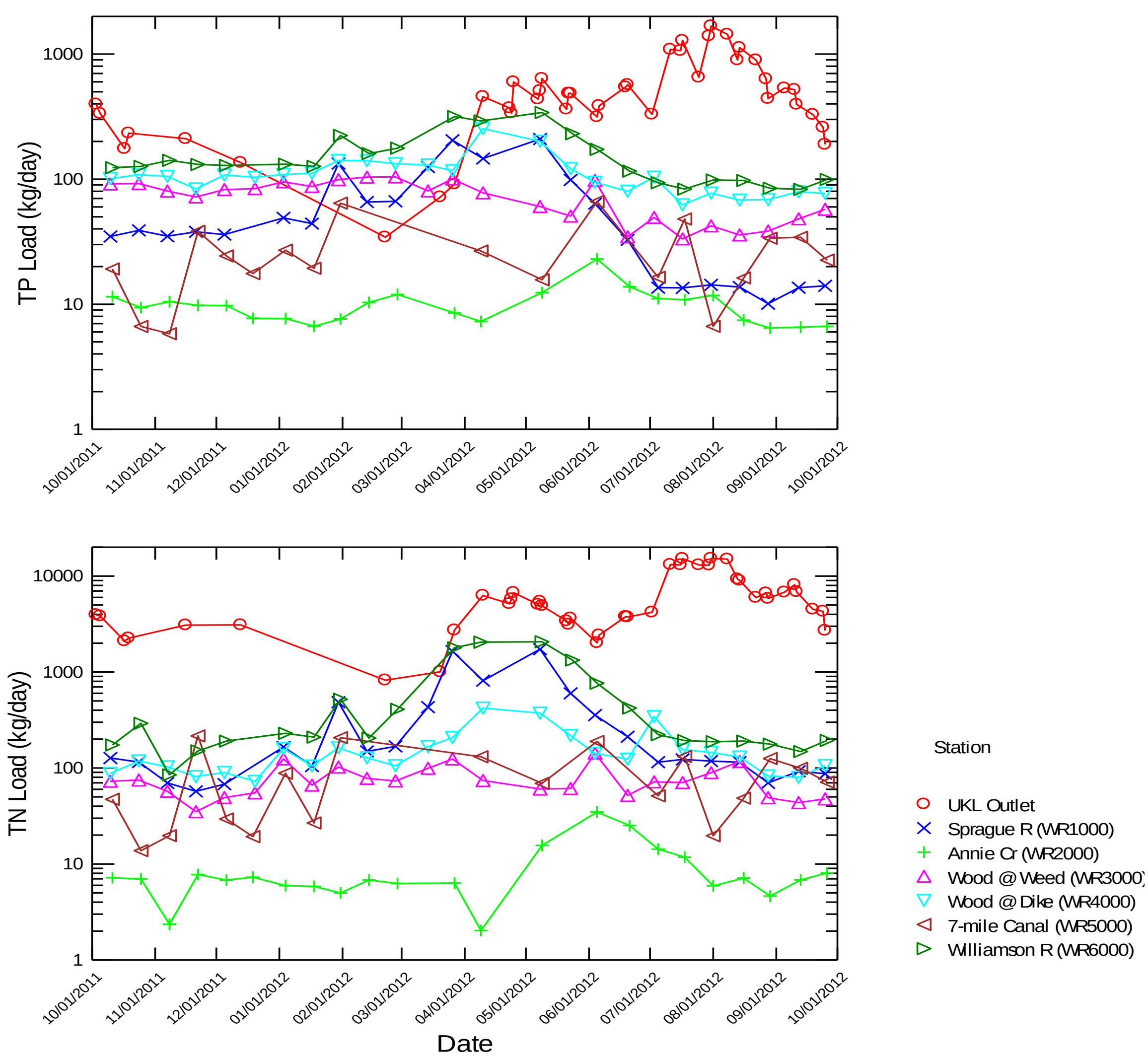

Figure 9. Seasonal TP and TN loading trends by station, HY 2012.

2012 Station Patterns

The 2012 nutrient loading pattern among stations was similar to that of the 1991-2011 sampling period (Figure 10). Also, as indicated above, TP and TN outflow loads tended to be higher than any individual inflow tributary loads during both 2012 and for the overall time period (1991-2011). Unlike 2010, when outflow TP and TN loads were lower overall than they were for the previous long-term period, similar to 2011, 2012 outflow loads were also similar to the long term distribution. However, comparisons are somewhat confounded by the lack of winter data for the outflow during 2011, which were available in 2012. As noted above, high UKL outlet loads reflect sediment regeneration and nitrogen fixation processes taking place in UKL.

Of the inflow tributaries, the Williamson River (WR6000) showed highest overall loading, with the 2012 TP and TN loading distributions somewhat lower than previous years. As with concentration, Annie Creek at Snow Park was consistently lower for both loading parameters (Figure 10). Sprague River TN load was more similar to the Williamson River TN load than it was for TP load (which was lower in the Sprague when compared to the Williamson), indicating that the Sprague River is contributing proportionally more nitrogen to the overall load. Both TP and TN loads in Sevenmile Canal were somewhat lower in 2012 than the long-term distribution, while Wood River TP was somewhat higher, and TN similar to the long-term distribution (Figure 10). TP and TN loading patterns in both the Williamson and Sprague Rivers tended to follow the general pattern in discharge (although loading appears to be more closely linked to discharge in the Sprague River than in the Williamson River), and as noted above for Outflow concentration, there is indication of cyclical trending over the period of record (Figure 11).

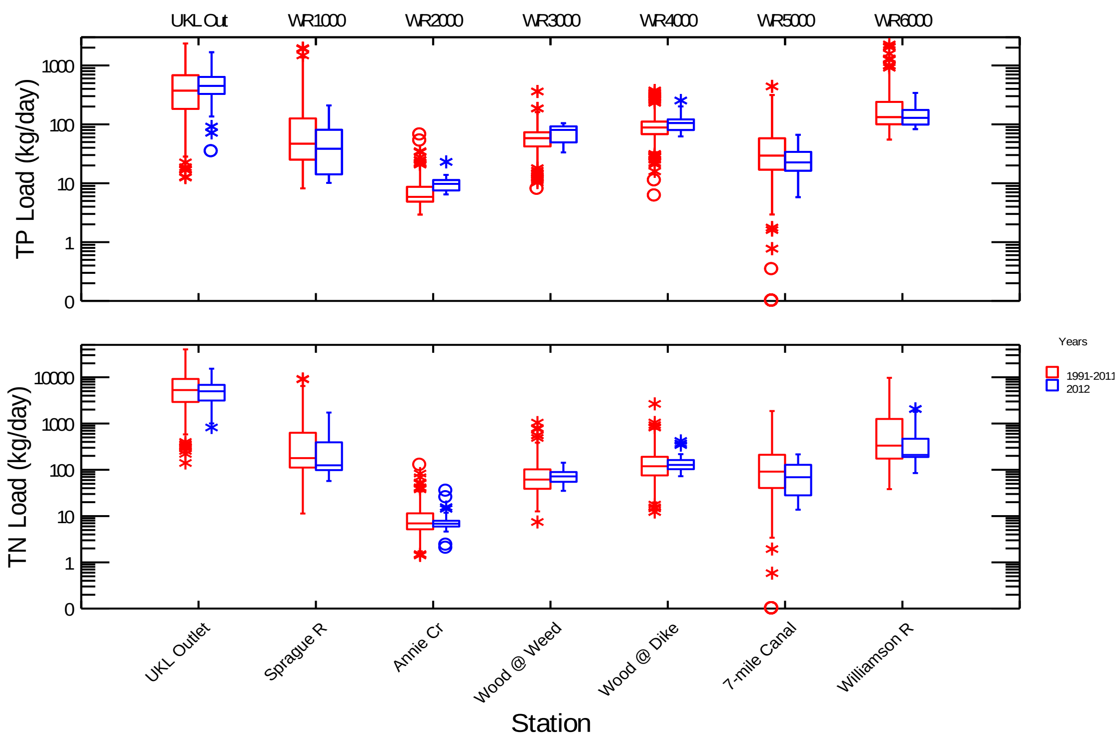

Figure 10. **Station distributions of TP and TN loading compared between 1991-2011 (red) and 2012 (blue). Note: for the outflow station KL0001 there are no samples from January to mid-April in HY2006, and for HY2007-2009 and HY2011 samples are missing between November and mid-April.**

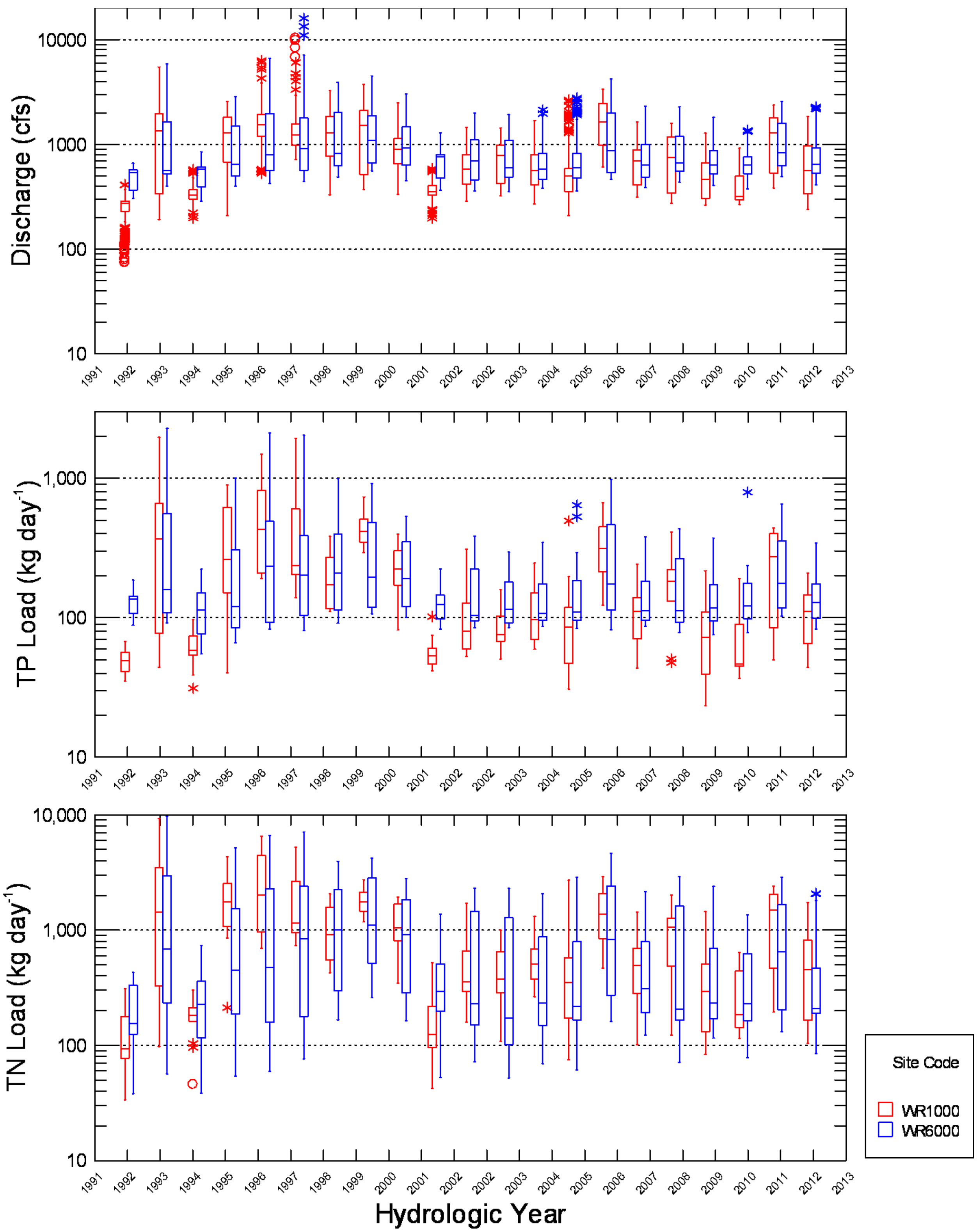

Figure 11. Distribution of Williamson River (WR6000) and Sprague River (WR1000) daily discharge (top panel), TP load (middle panel), and TN load (bottom panel) for the January-May inflow period, 1992-2012.

Inter-annual Patterns, 1991-2012

Although it is beyond the scope of this 2012 data summary report to analyze the inter-annual trends in detail, 1991-2012 comparisons for all sampling stations for three periods (all dates, the June-September period, and the Jan-May period) are shown for reference in Figures 11 to 24. Briefly, in 2012 the June -September UKL outflow TP loads were higher than 2011 but still generally lower than previous years (Figure 12). Similarly, June-September TN loads were somewhat higher than 2011 but were also lower than previous years (Figure 19). Note that for the UKL outlet station, the June-September period provides the most consistent inter-annual comparison due to changes in the winter and early spring sampling frequency over the period of record.

June-September and winter TP and TN loading distributions for the Sprague River were much lower than 2011 and tended to be among the lowest relative to previous years (Figure 13 and Figure 20). Similarly Williamson River TP and TN loading distributions were among the lowest for the June-September period, but intermediate for the January through May period, and were lower overall than 2011 (Figure 18 and Figure 25). TN loading distributions for the Wood River stations during 2012 tended to be intermediate for the period of record, but was higher at Weed Rd. than the previous several years (Figure 22 and Figure 23). The Wood River TP loading distribution for 2012 tended to be intermediate when compared to previous years; however they were noticeably lower than 2011for the June-September period (Figure 15 and Figure 16). Seven Mile Canal TP and TN loading during 2012 was similar to previous years (Figure 17 and Figure 24), and overall loads for Annie Creek during the Jan-May period were higher than 2011 and 2010 but tended to be intermediate compared to previous years for the June-September period (Figure 14and Figure 21).

Inter-annual comparisons of nutrient concentration and loading at the various UKL inflow stations requires refined estimation of loading using multiple regression based-algorithms that represent concentration variations associated with flow (i.e., magnitude as well as ascending/descending limb of hydrograph), season (i.e., Julian day), and year (e.g., Walker and Havens 2003). A comprehensive analysis of time-series trends as well as hydrologic and nutrient budgets for UKL has been completed through 2010 (Walker et al. 2012).

SUMMARY

With the addition of 2012 data, the UKL tributary nutrient and loading database now includes 22 years of data, including the years 1991-2012. As with the UKL water quality database, such a long-term monitoring program is essential for assessing change relative to management programs, as well as for understanding inter-annual dynamics. Also similar to recommendations for the UKL water quality database, continued monitoring is recommended to accommodate the restoration time-frame for Klamath Basin activities and to increase statistical power (sample size) for inter-variable analyses. While this data summary report is intended to provide an update of the long-term data base with 2012 tributary and outflow data, Walker et al. (2012) provide a more detailed and comprehensive analysis of the long-term UKL tributary database including statistical trend analyses and construction of hydrologic and nutrient budgets for UKL using the entire 1991-2010 dataset (Walker et al. 2012). A similar comprehensive treatment of the data is recommended at five year intervals.

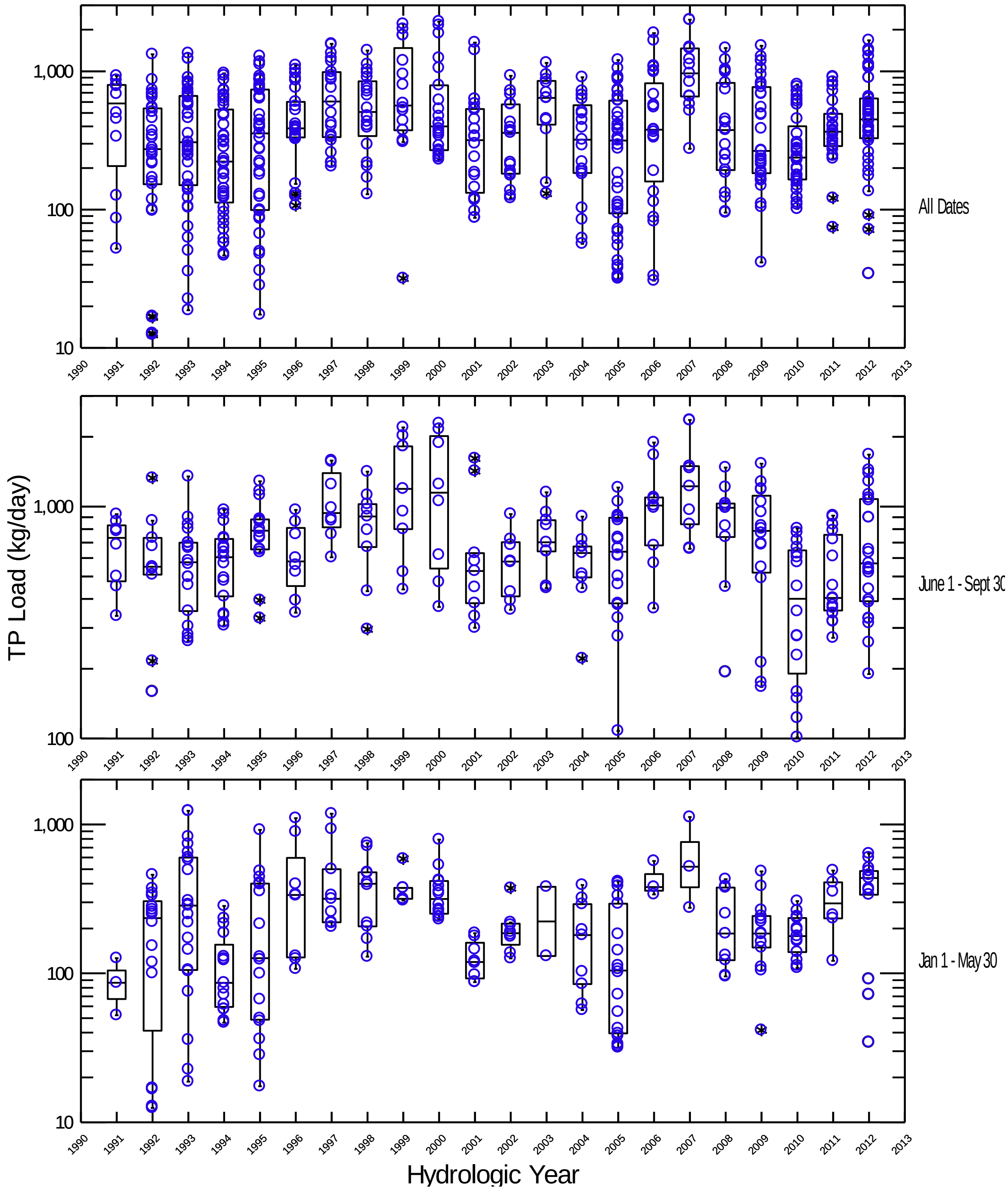

Figure 12. Annual and seasonal distributions of UKL Outlet TP loading, 1991-2012. Note: in HY2006, there are no samples from January to mid-April and in HY2007-2008 and 2011 there are no samples from November to mid-April.

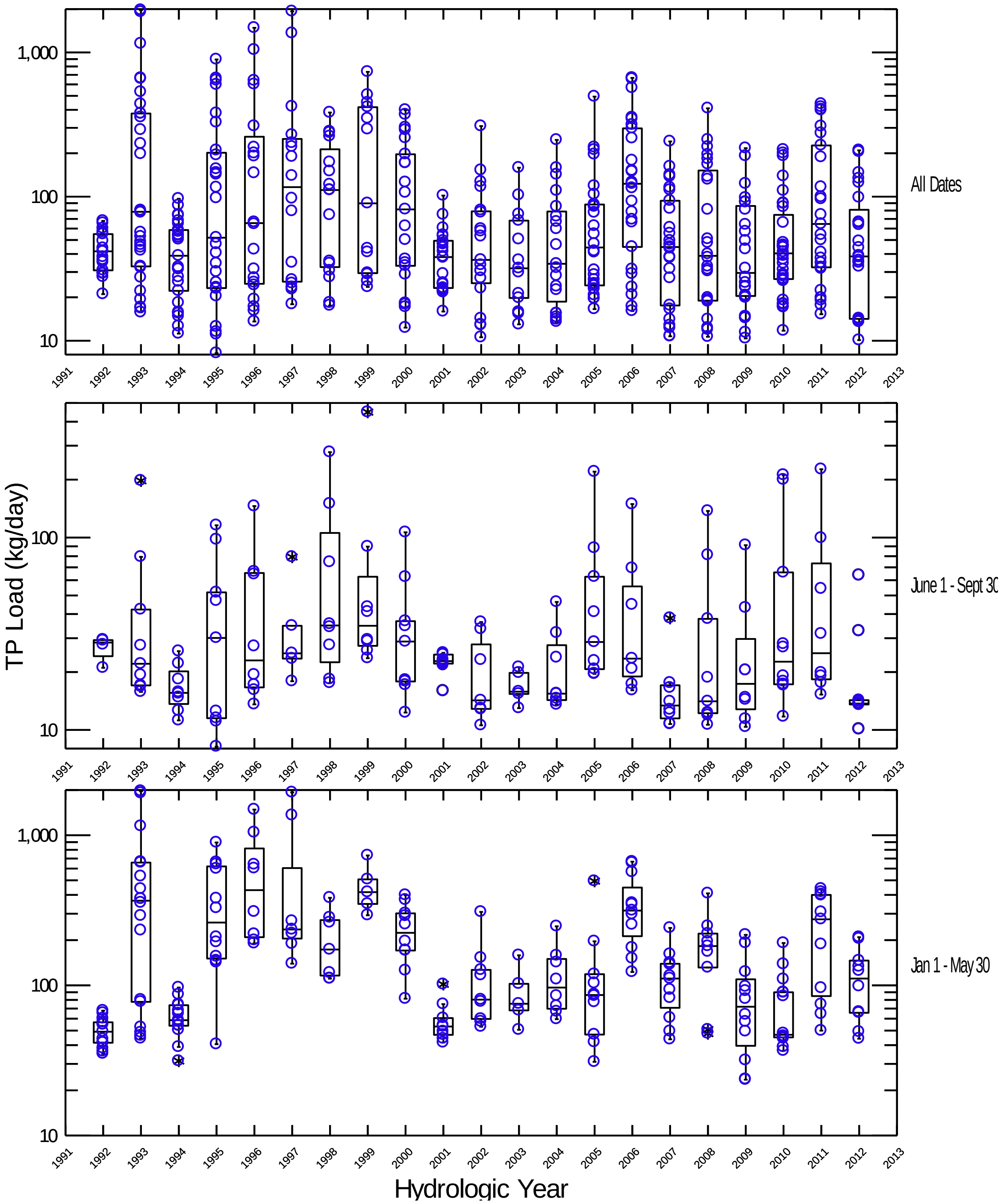

Figure 13. Annual and seasonal distributions of Sprague River TP loading, 1992-2012.

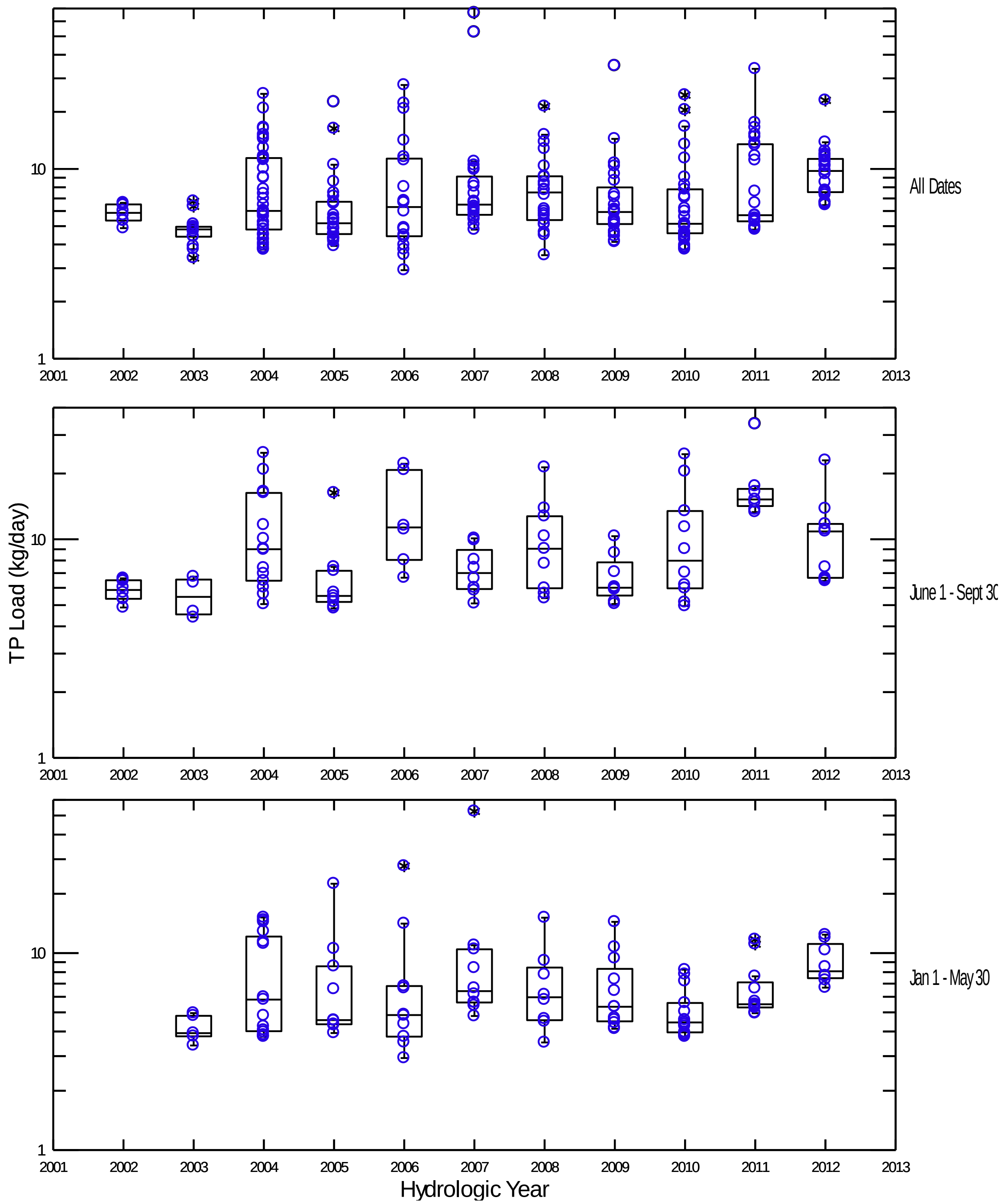

Figure 14. Annual and seasonal distributions of Annie Creek TP loading, 2002-2012.

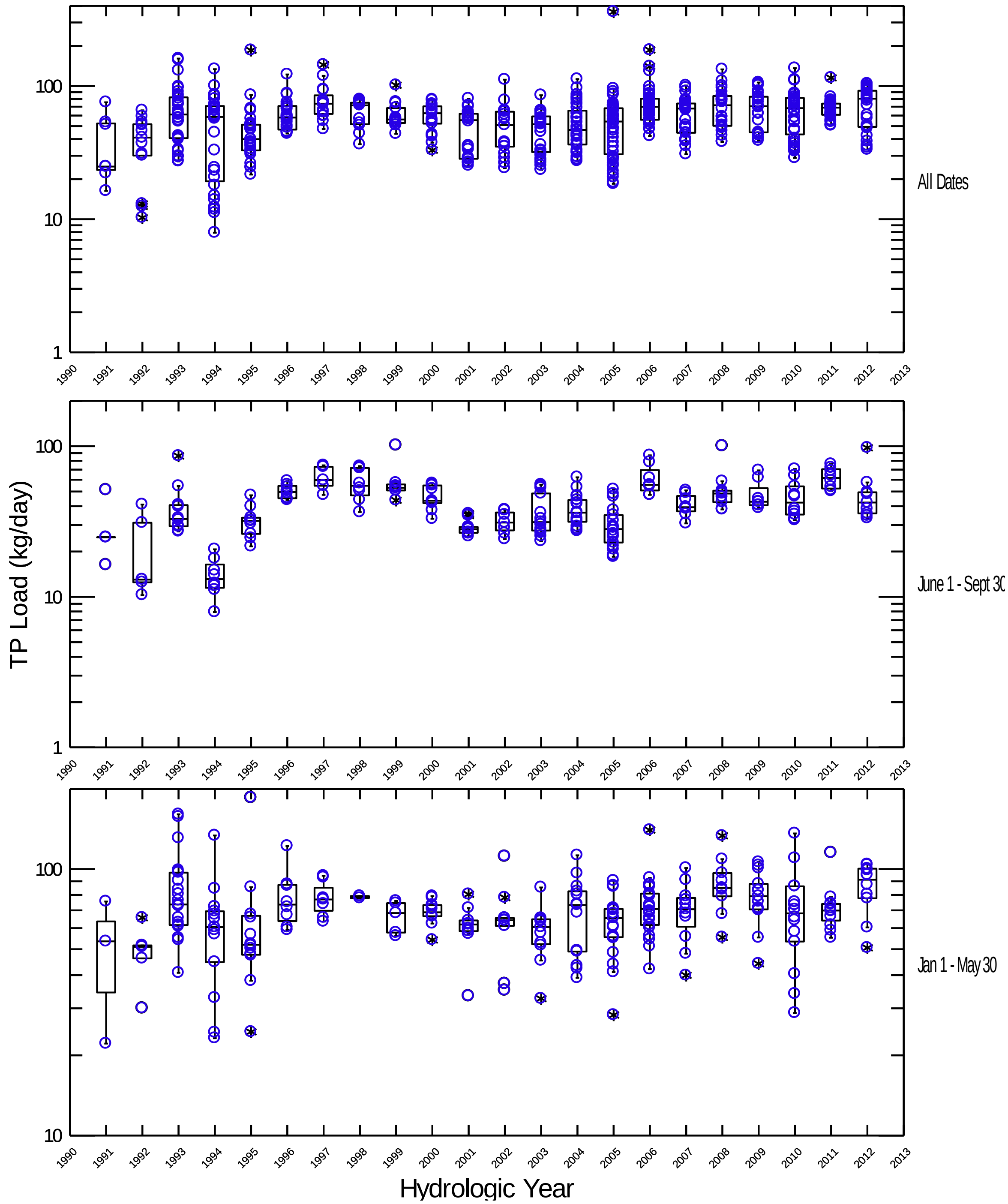

Figure 15. Annual and seasonal distributions of Wood River at Weed Rd. TP loading, 1991-2012.

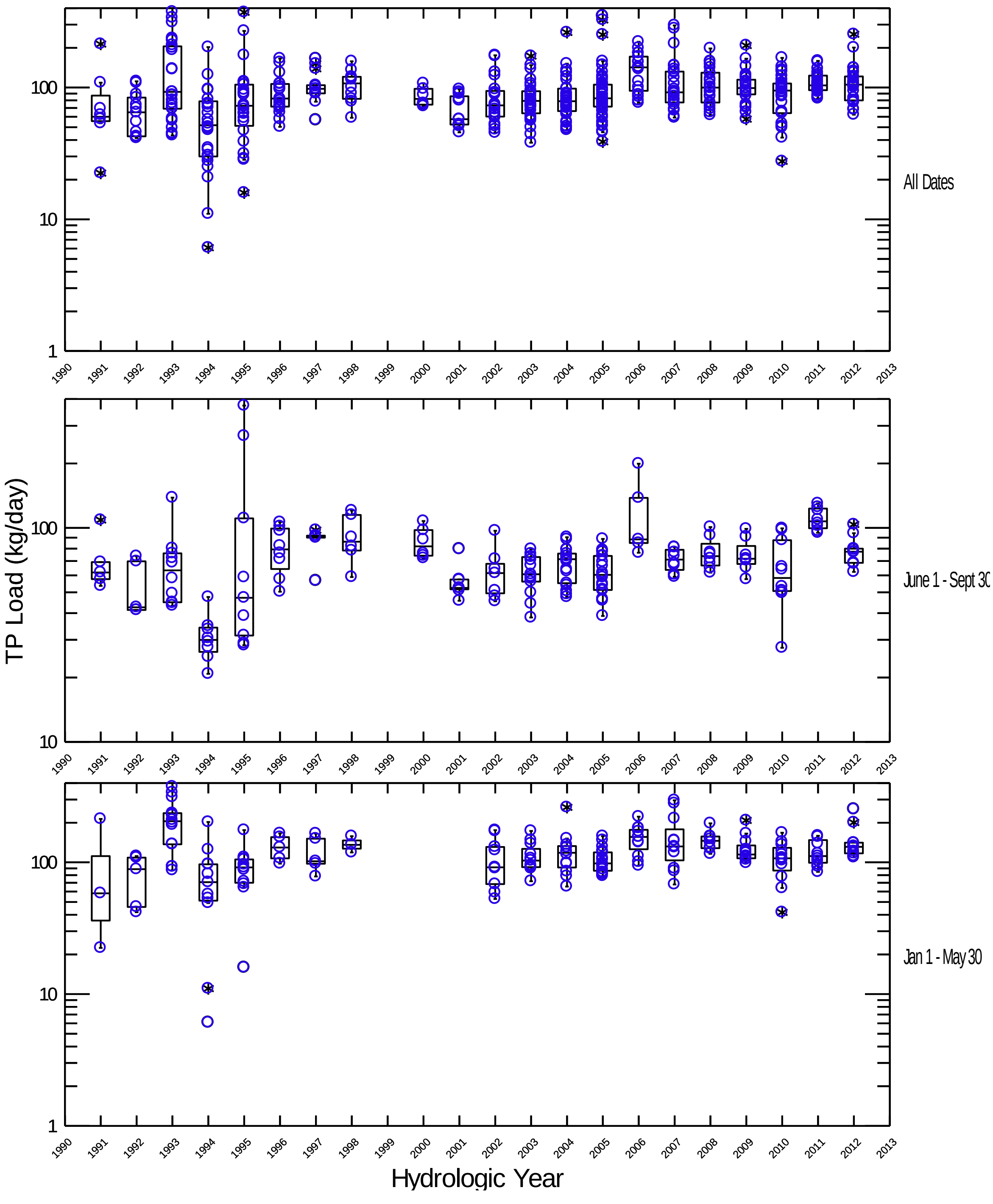

Figure 16. Annual and seasonal distributions of Wood River at Dike Rd. TP loading, 1991-2012.

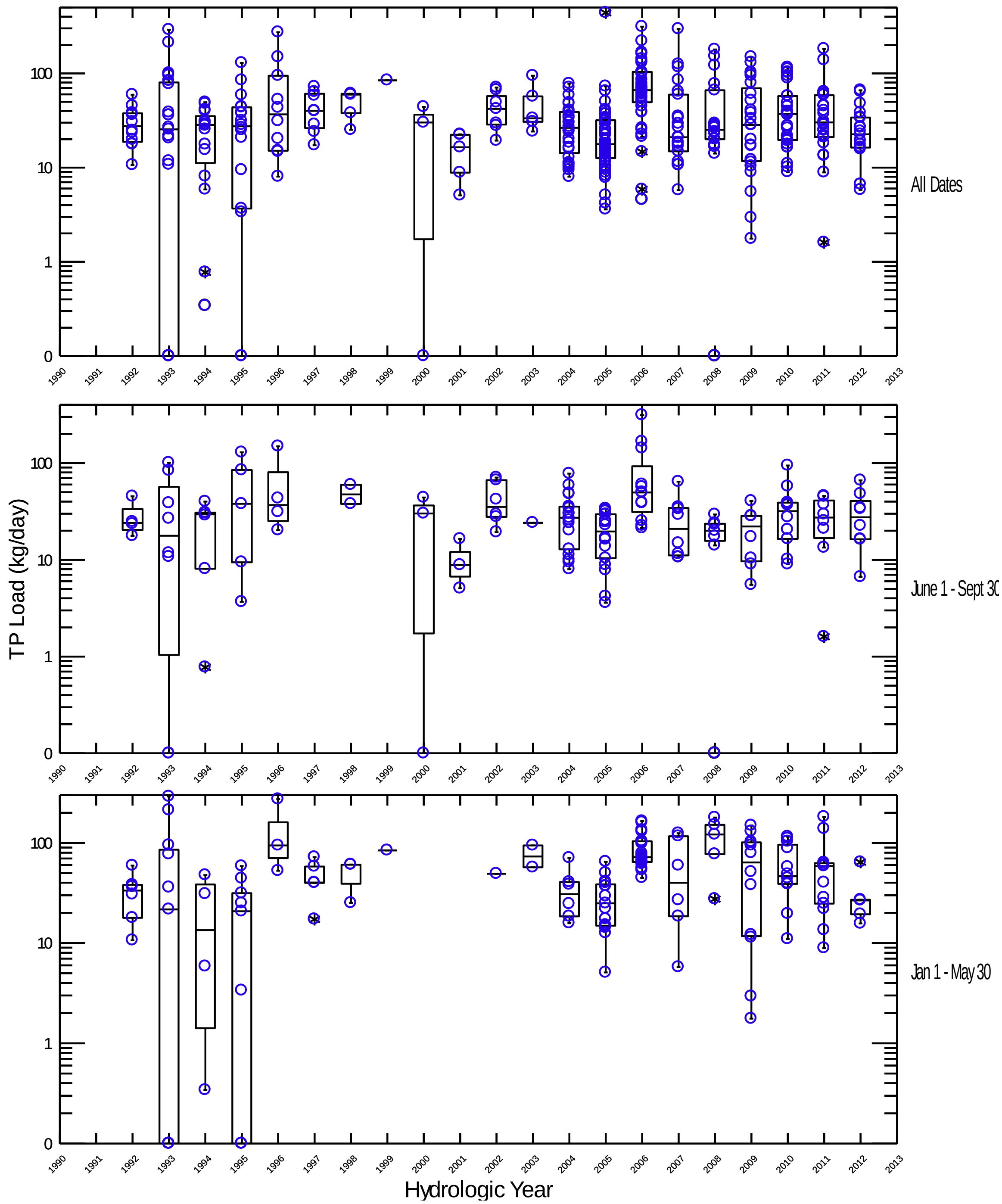

Figure 17. Annual and seasonal distributions of Seven Mile Canal TP loading, 1992-2012. Note that occurrences of zero load are due to lake-backwater effects when no flow is measured at the sampling location

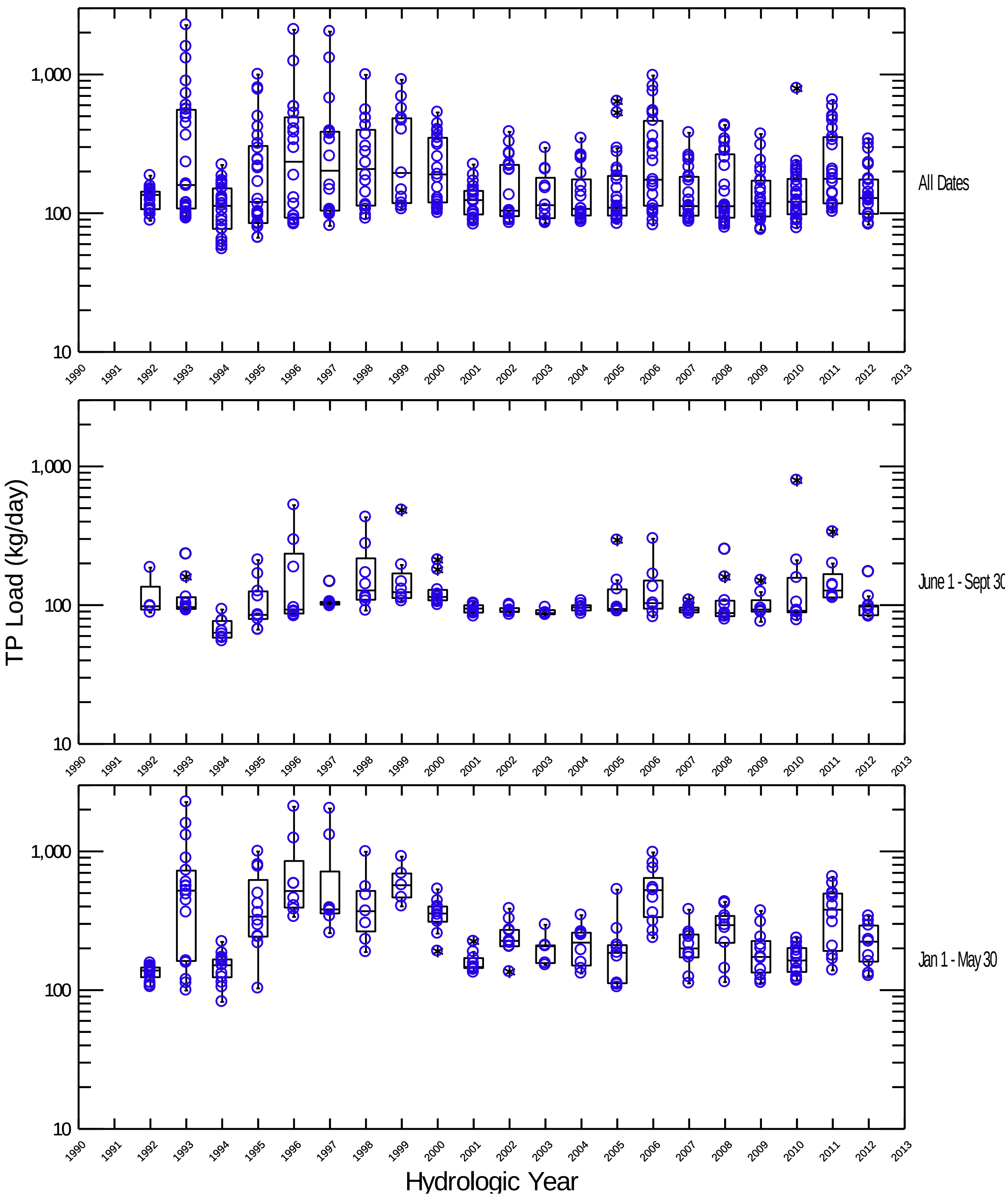

Figure 18. Annual and seasonal distributions of Williamson River TP loading, 1992-2012.

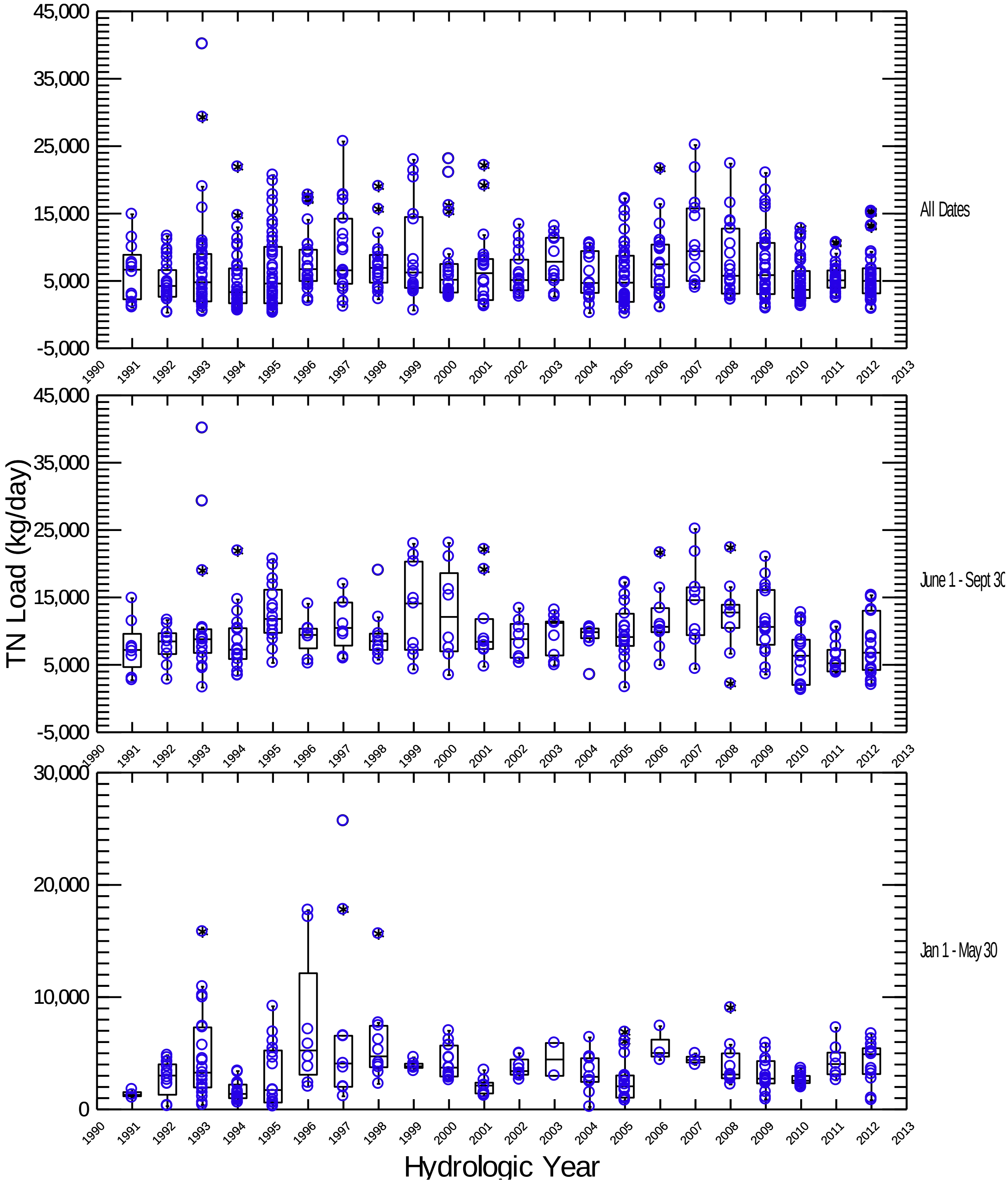

Figure 19. Annual and seasonal distributions of UKL Outlet TN loading, 1991-2012. Note: in HY2006, there are no samples from January to mid-April and in HY2007-2008 and 2011 there are no samples from November to mid-April.

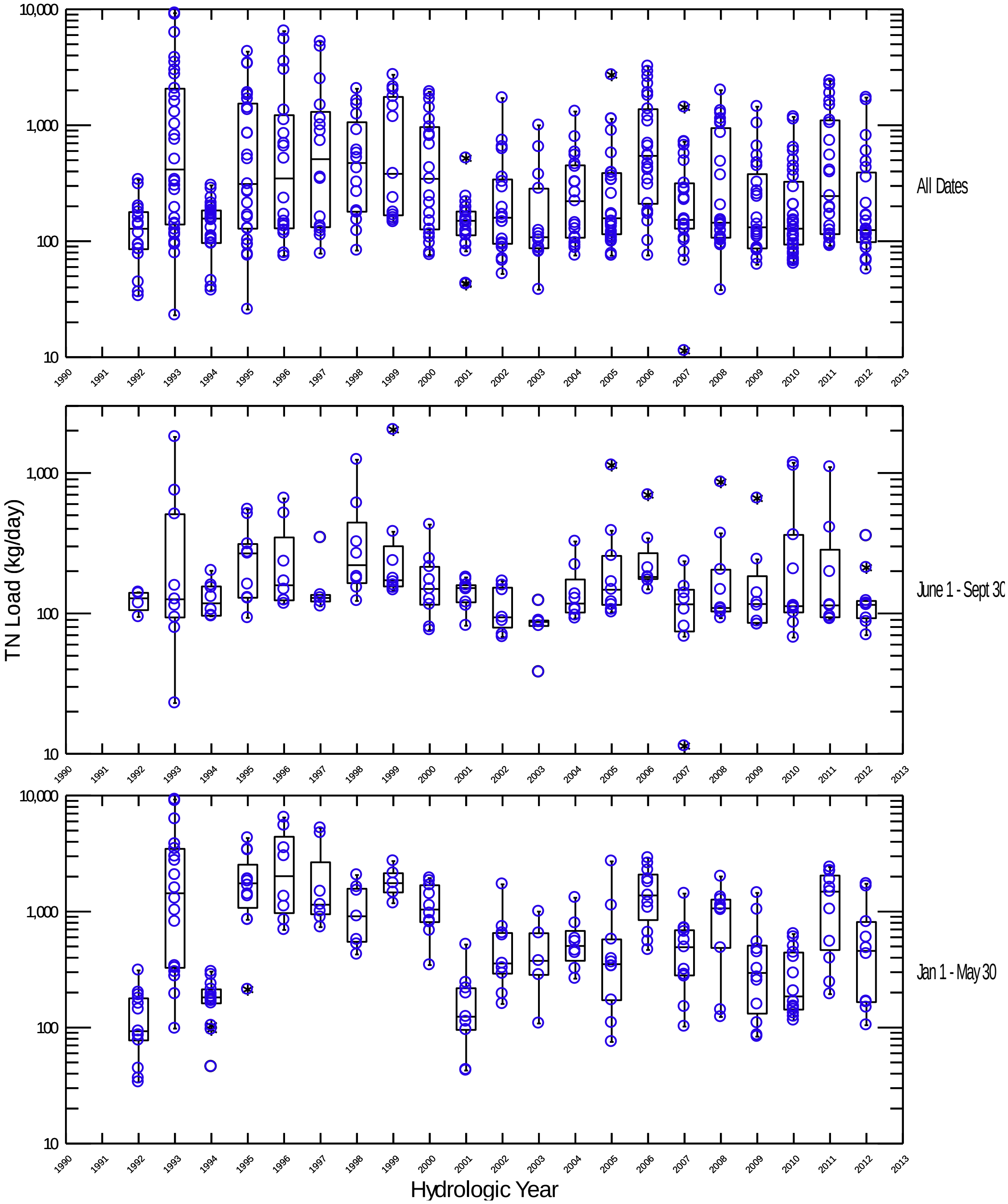

Figure 20. Annual and seasonal distributions of Sprague River TN loading, 1992-2012.

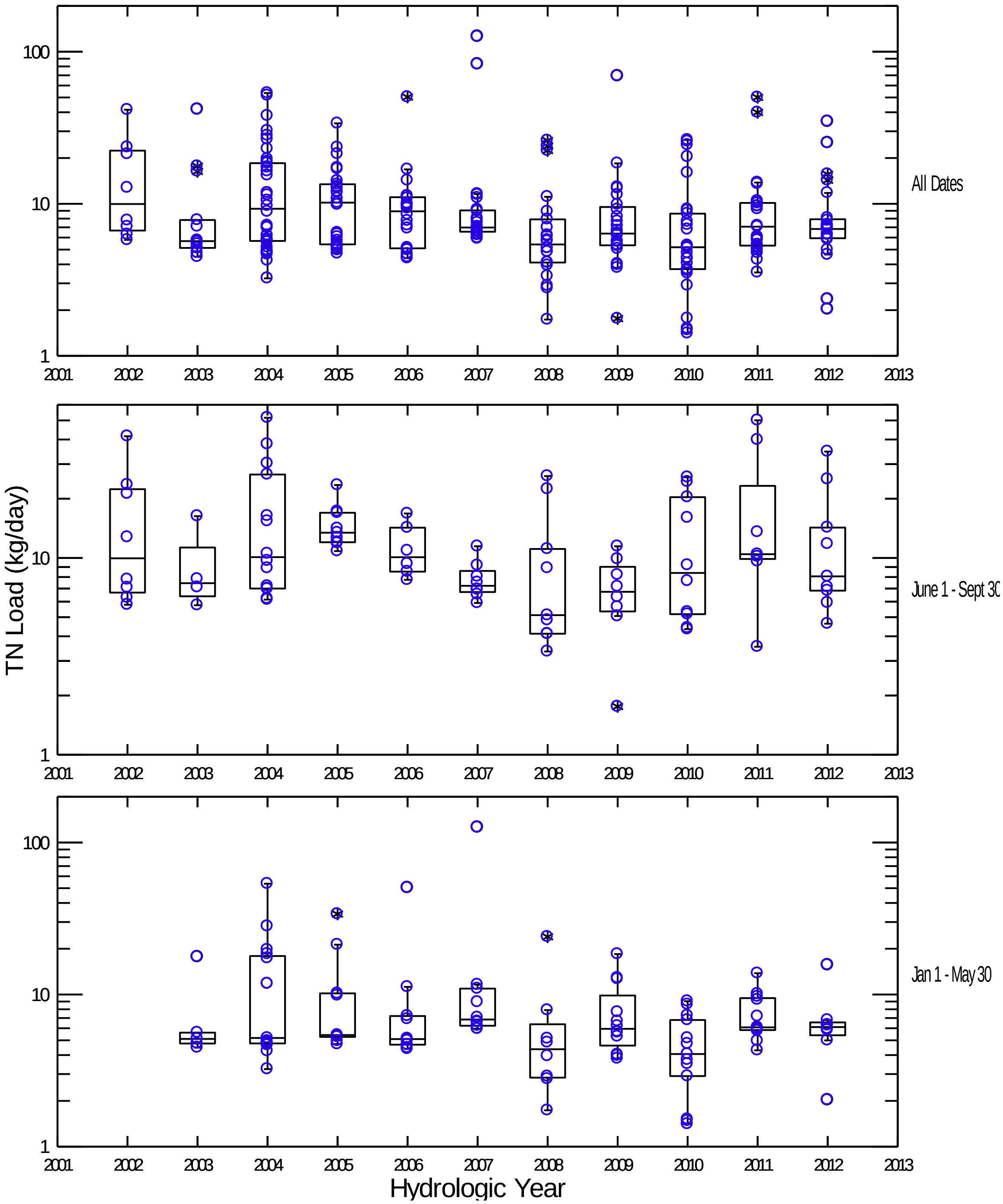

Figure 21. Annual and seasonal distributions of Annie Creek TN loading, 2002-2012.

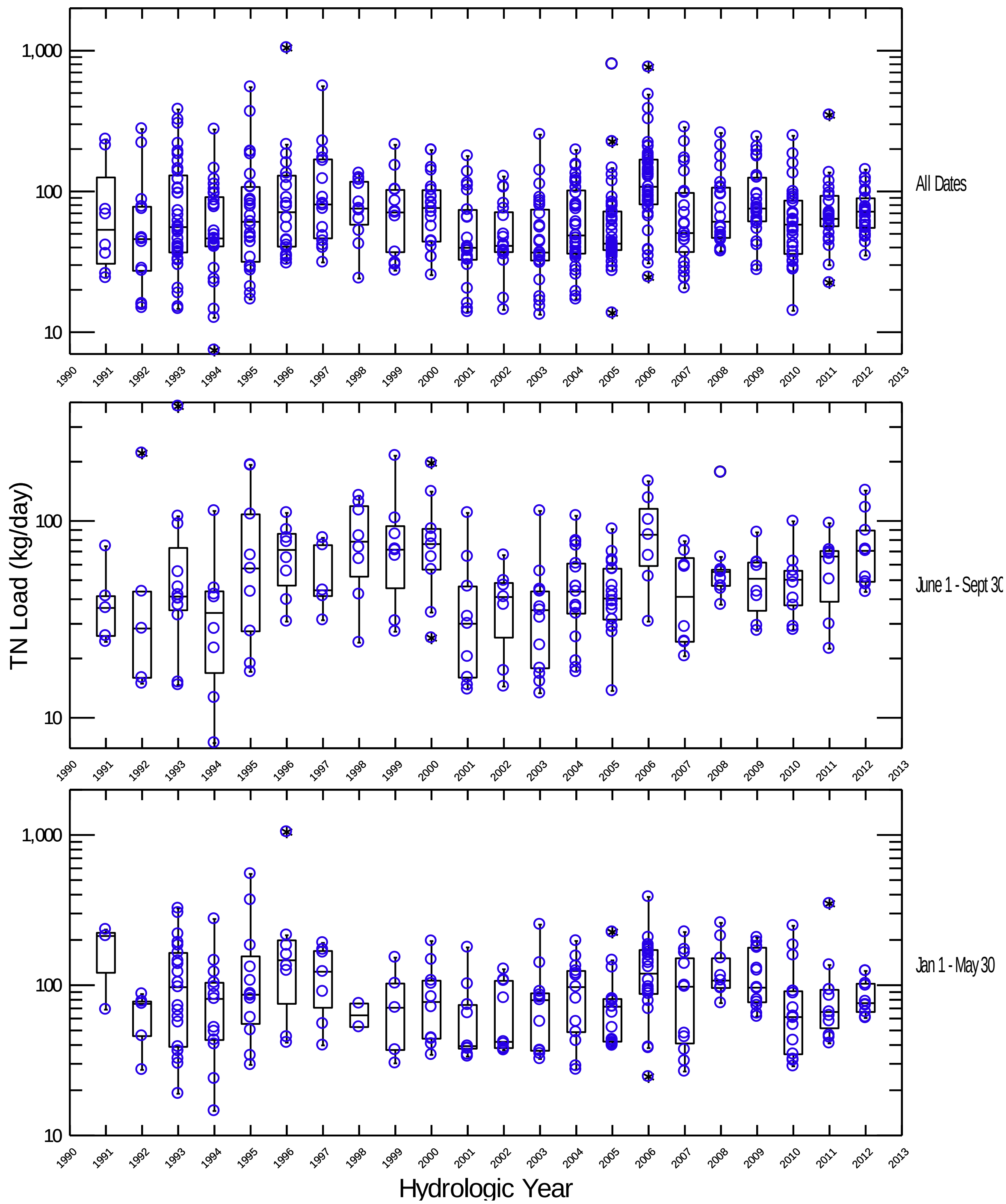

Figure 22. Annual and seasonal distributions of Wood River at Weed Rd. TN loading, 1991-2012.

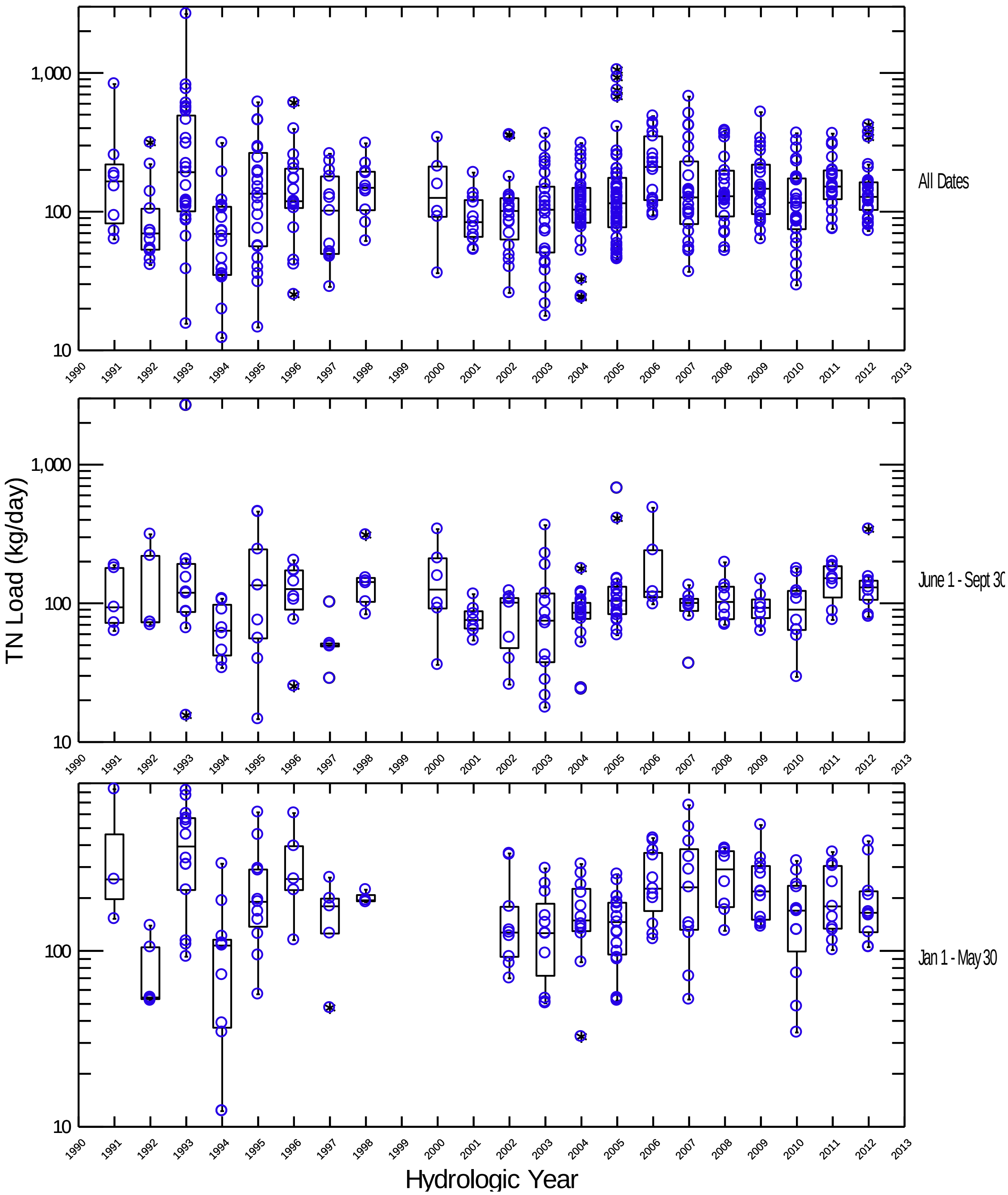

Figure 23. Annual and seasonal distributions of Wood River at Dike Rd. TN loading, 1991-2012.

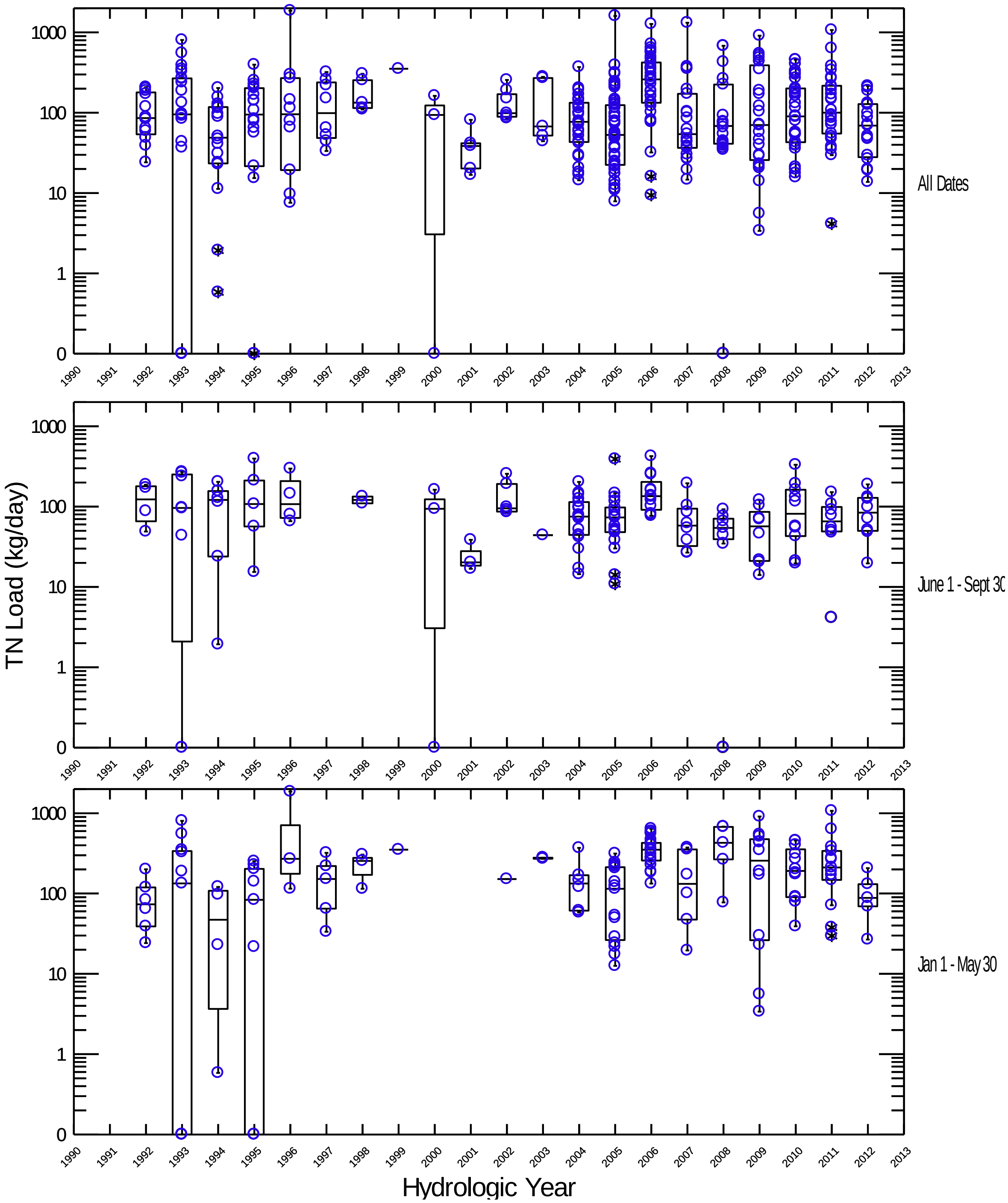

Figure 24. Annual and seasonal distributions of Seven Mile Canal TN loading, 1992-2012. Note that occurrences of zero load are due to lake-backwater effects when no flow is measured at the sampling location.

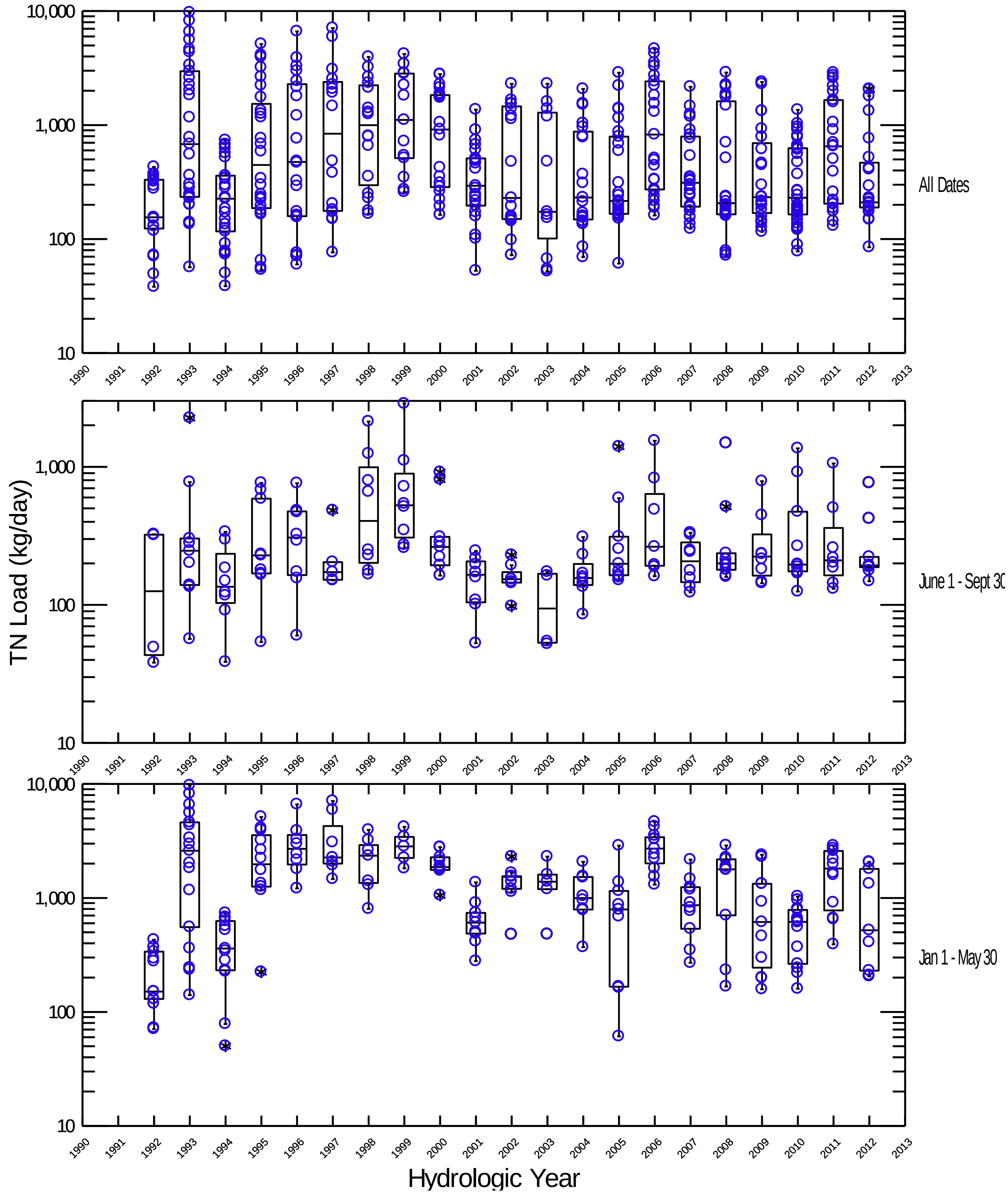

Figure 25. Annual and seasonal distributions of Williamson River TN loading, 1992-2012.

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