

Impacts of Stream Hydrologic Characteristics on Ambient Water Quality and Aquatic Health in the Austin, Texas Area

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Abstract

Water quality and aquatic health data collected as part of the City of Austin (COA) Environmental Integrity Index (EII) were compared to stream flow characteristics using forty-four metrics derived from daily average flows collected by the U.S. Geological Survey (USGS) and COA. Water quality data were highly correlated with impervious cover ($r = -0.911$). Most of the flow metrics were correlated with each other, as was expected, resulting in a redundancy of information and the possibility of cross-correlation when performing additional analyses. A statistical relationship between aquatic life data and three flow metrics, fraction of time the creek is dry, single pass baseflow ratio and the natural log of the 90th percentile flow, was developed based on the correlations and what metrics can be predicted reliably with existing watershed models. The resulting model has an adjusted $r^2 = 0.702$. This model will be used to predict aquatic life potential in Austin-area streams using modeled flows under different development scenarios.

Introduction

Changing land uses associated with urbanization can have detrimental effects on urban and suburban streams, both hydrologically and biologically. For many years urban watershed management and planning has focused on controlling peak runoff rates associated with infrequent flood-producing events, primarily for flooding concerns, and more recently on addressing non-point source pollutants. However, controlling the peaks of these rare events does little to mitigate the hydrologic changes associated with smaller rainfall events caused by urbanization or the biological impacts related to the changes in flow regimes.

Urbanization of a watershed is often expressed as a function of impervious cover. However, impervious cover may not always be an accurate predictor of the changes in hydrology or the changes in the biologic community. While the hydrologic changes associated with the changes in impervious cover and urbanization may be modeled (and often are), the impacts of changes in impervious cover on stream biology are often not considered when new developments are proposed. Urban planners have suggested

methods to control runoff from post-development conditions that may mimic pre-development conditions in such a way as to minimize the impacts on biological communities (Roesner and Rohrer, 2006).

Most of the studies relating flow to biological health have focused on perennial streams in the Pacific Northwest and the southeastern United States. Little work has been done to address the impacts on biological health in areas with predominantly intermittent or ephemeral streams, like the area in and around Austin, Texas. Since the biological communities in these streams evolved under very different conditions as compared to other study areas, hydrologic factors affecting these biological communities may be very different.

Poff and Ward (1989) examined daily flow records from seventy-eight USGS stations across the United States for variability and the pattern of the flood regime. They demonstrated that streams could be characterized into different classes by their hydrologic characteristics and that these could theoretically have an impact on the biological community. They were unable to quantitatively relate stream biology to hydrology due to the lack of consistent data.

Richter, et al. (1996) proposed the Indicators of Hydrologic Alteration (IHA) as a standard set of parameters to evaluate hydrologic conditions that may relate to stream biology. These “biohydrologic” terms were meant to help build a common vocabulary between hydrologists and aquatic biologists. These parameters could be broadly grouped into magnitude timing, magnitude duration, extreme timing, magnitude frequency/duration, and frequency rate of change. The authors demonstrated that these parameters could be used to assess hydrologic changes to streams after alteration by dam construction on the Roanoke River in North Carolina.

Clauses and Biggs (1997) examined the relationship between stream biology and hydrology in New Zealand. They also looked at the correlation of hydrologic parameters using principal component analyses. It was found that many of the hydrologic parameters were correlated and could be combined into principal components. It was suggested that the fraction of flow exceeding three times the mean be used as the primary flow index to classify biological habitat in New Zealand.

Scoggins (2000) demonstrated that hydrologic parameters proposed by both Poff and Ward (1989) and Richter, et al. (1996) could be used to characterize streams in central Texas and that these parameters could be related to stream biology. Scoggins also reported that the stream characteristics differ significantly from those in northern Virginia and that interpretation of stream health in one region using methods developed in another could result in misleading interpretations. This is especially true if abiotic hydrologic conditions are controlling stream health as opposed to biotic conditions or abiotic non-point source pollution.

Booth, et al. (2001, 2004) studied the effects of urbanization on stream health in the Puget Sound region in Washington. Three hydrologic factors were examined: the fraction of the year that the annual mean was exceeded ($T_{Q_{mean}}$), the fraction of a multiple year period that the discharge exceeded a specified flood quantile (in this case the 6-month event, $T_{Q_{0.5-yr}}$), and the coefficient of variation of the annual maximum flood. All of these factors were inversely proportional to the degree of urbanization but $T_{Q_{mean}}$ was also influenced by watershed size. Computation of $T_{Q_{0.5-yr}}$ also requires a long (10 years) sub-daily flow record, preferably sub-hourly, to be meaningful. The study also found that $T_{Q_{mean}}$ and $T_{Q_{0.5-yr}}$ were directly related to the benthic index of biological integrity (B-IBI).

Olden and Poff (2003) examined the redundancy in proposed hydrologic indices using the same sites used by Poff and Ward (1989). It was found that many of the 171 hydrologic indices examined were correlated and redundancy could be reduced by using principal component analyses to reduce collinearity. While the suggested framework could be useful in selecting indices, the authors noted that professional

judgment should be relied upon when selecting indices to address specific biological questions. The authors also indicated that transferring selected indices between hydroclimatic regions and/or stream types was still an open question. Perennial streams exhibited less variance in index selection than intermittent streams. It may be possible to transfer indices for perennial streams across hydroclimatic regions but not for intermittent streams. Indices developed for one stream type should not be used for other stream types.

Roesner and Rohrer (2006) extended the work of Booth et al. (2001, 2004) and presented a protocol whereby watershed planners and managers could design projects to take stream health into consideration based on hydrology. The authors suggested using the framework presented by Olden and Poff (2003) when selecting significant hydrologic metrics related to aquatic biology, while still using intuitive selection criteria.

DeGaspari et al. (2009) also built on the work of Booth et al. (2001, 2004) and others in the Puget Sound area. The researchers used hydrologic modeling to simulate hydrologic metrics under different development scenarios. These were used to determine which scenarios best met management plans with respect to aquatic life. While this was found to be a useful tool, hydrologic metrics that can be reliably predicted by the model should be selected over other metrics that cannot be predicted well.

The main focus of this study is to find a stochastic relationship between stream hydrology and aquatic life that is valid in the Austin, Texas area. Correlations between water quality measures, impervious cover and stream flow metrics will be examined also. The results of this study will allow water quality professionals and planners to evaluate the impacts of different development scenarios in aquatic health in this unique hydroclimatic area.

Methods

The area in and around Austin is uniquely suited for this study for several reasons. First, COA and USGS have participated in a cooperative monitoring program for many years and there are daily stream flow records for some area streams dating back to the 1950s. Second, the City has impervious cover estimates for many of these same watersheds over time, allowing the temporal changes in impervious cover to be included in the analyses. Last, the City has been collecting aquatic life data across the area for its Environmental Integrity Index (EII) since the early 1990s. Taken together, these datasets represent a unique combination and allow for analyses of both stream flow and biological health across both the urban gradient and through time. A summary of available flow (Q), water quality (WQ), aquatic life (AQL) and impervious cover (IC) data between 1958 and 2007, divided by period, is presented in Table 1.

Flow Data

USGS/COA daily flow records were divided into nine periods associated with existing impervious cover estimates: 1958-1968, 1969-1975, 1976-1985, 1986-1992, 1993-1996, 1997-1998, 1999-2001, 2002-2004, and 2005-2007. Impervious cover estimates for these periods were calculated at various times using potentially different methods and no attempt was made to verify them or check for consistency. Each period was analyzed for each watershed to determine the amount of valid flow data. Flow statistics were computed for the daily flow records. Daily records were used because the period of record for daily data is longer and more complete than the unit value data. (Further analyses using unit value data may be performed in the future.) The flow statistics computed are presented in Table 2. These flow statistics were selected after a review of prior research but did not rely upon the conclusions of those studies since they were often related to other flow conditions or hydroclimatic region. While the flow statistics list is not exhaustive, it does include the most common statistics used in prior studies.

Table 1: Availability of flow (Q), water quality scores (WQ), aquatic life scores (AQL) and impervious cover data in the Austin, Texas, area between 1958 and 2007

Station ID	Station Name	1958-1968				1969-1975				1976-1985			
		Q	WQ	AQL	IC	Q	WQ	AQL	IC	Q	WQ	AQL	IC
08154700	Bull Creek at Loop 360									X			X
08155200	Barton Creek at SH 71									X			X
08155240	Barton Creek at Lost Creek Blvd.												
08155300	Barton Creek at Loop 360									X			X
08155400	Barton Creek above Barton Springs												
08156700	Shoal Creek at Northwest Park					X				X			X
08156800	Shoal Creek at 12th Street									X			X
08157000	Waller Creek at 38th Street	X				X				X			X
08157500	Waller Creek at 23rd Street	X				X				X			X
08157600	East Bouldin Creek at S. 1st Street												
08157700	Blunn Creek near Little Stacy Park												
08158050	Boggy Creek at US 183									X			
08158600	Walnut Creek at Webberville Road	X			X	X				X			X
08158700	Onion Creek near Driftwood, TX									X			
08158800	Onion Creek at Buda, TX									X			
08158810	Bear Creek below FM 1826									X			X
08158827	Onion Creek at Twin Creeks Road												
08158840	Slaughter Creek at FM 1826									X			
08158920	Williamson Creek at Oak Hill, TX									X			
08158930	Williamson Creek at Manchaca Road									X			
08158970	Williamson Creek at Jimmy Clay Road					X				X			X
08159000	Onion Creek at US 183									X			
FBU	Bear Creek at FM 1826												
FTB	Fort Branch Creek at Webberville Road												

Table 1 (cont.): Availability of flow (Q), water quality scores (WQ), aquatic life scores (AQL) and impervious cover data in the Austin, Texas, area between 1958 and 2007

Station ID	Station Name	1986-1992				1993-1996				1997-1998			
		Q	WQ	AQL	IC	Q	WQ	AQL	IC	Q	WQ	AQL	IC
08154700	Bull Creek at Loop 360	X			X	X	X	X	X	X	X		X
08155200	Barton Creek at SH 71	X	X		X	X	X		X	X	X	X	X
08155240	Barton Creek at Lost Creek Blvd.	X	X		X	X	X	X	X	X	X	X	X
08155300	Barton Creek at Loop 360	X			X	X			X	X	X		X
08155400	Barton Creek above Barton Springs							X		X	X	X	
08156700	Shoal Creek at Northwest Park												
08156800	Shoal Creek at 12th Street	X			X	X	X	X	X	X			X
08157000	Waller Creek at 38th Street	X			X	X			X				
08157500	Waller Creek at 23rd Street				X	X			X	X	X		X
08157600	East Bouldin Creek at S. 1st Street							X		X			
08157700	Blunn Creek near Little Stacy Park								X				
08158050	Boggy Creek at US 183	X			X	X			X	X			X
08158600	Walnut Creek at Webberville Road	X			X	X	X	X	X	X	X	X	X
08158700	Onion Creek near Driftwood, TX	X				X				X	X		X
08158800	Onion Creek at Buda, TX	X				X							
08158810	Bear Creek below FM 1826	X			X	X			X	X			X
08158827	Onion Creek at Twin Creeks Road							X					
08158840	Slaughter Creek at FM 1826	X			X	X			X	X			X
08158920	Williamson Creek at Oak Hill, TX	X			X	X			X				
08158930	Williamson Creek at Manchaca Road												
08158970	Williamson Creek at Jimmy Clay Road	X			X								
08159000	Onion Creek at US 183	X				X				X		X	
FBU	Bear Creek at FM 1826					X				X			
FTB	Fort Branch Creek at Webberville Road												

Table 1 (cont.): Availability of flow (Q), water quality scores (WQ), aquatic life scores (AQL) and impervious cover data in the Austin, Texas, area between 1958 and 2007

Station ID	Station Name	1999-2001				2002-2004				2005-2007			
		Q	WQ	AQL	IC	Q	WQ	AQL	IC	Q	WQ	AQL	IC
08154700	Bull Creek at Loop 360	X	X	X	X	X	X	X	X	X		X	
08155200	Barton Creek at SH 71	X	X	X	X	X	X	X	X	X		X	
08155240	Barton Creek at Lost Creek Blvd.	X	X	X	X	X	X	X	X	X		X	
08155300	Barton Creek at Loop 360	X			X	X	X		X	X			
08155400	Barton Creek above Barton Springs	X		X		X		X		X		X	
08156700	Shoal Creek at Northwest Park												
08156800	Shoal Creek at 12th Street	X	X	X		X	X		X	X		X	
08157000	Waller Creek at 38th Street												
08157500	Waller Creek at 23rd Street	X	X	X		X	X	X	X	X		X	
08157600	East Bouldin Creek at S. 1st Street	X				X			X	X		X	
08157700	Blunn Creek near Little Stacy Park	X				X			X	X		X	
08158050	Boggy Creek at US 183	X										X	
08158600	Walnut Creek at Webberville Road	X	X	X		X	X	X	X	X		X	
08158700	Onion Creek near Driftwood, TX	X			X	X	X	X	X	X		X	
08158800	Onion Creek at Buda, TX							X					
08158810	Bear Creek below FM 1826	X		X	X			X		X			
08158827	Onion Creek at Twin Creeks Road			X				X				X	
08158840	Slaughter Creek at FM 1826	X			X	X			X	X		X	
08158920	Williamson Creek at Oak Hill, TX					X			X	X			
08158930	Williamson Creek at Manchaca Road	X				X				X			
08158970	Williamson Creek at Jimmy Clay Road									X			
08159000	Onion Creek at US 183	X			X	X		X	X	X			
FBU	Bear Creek at FM 1826	X				X				X			
FTB	Fort Branch Creek at Webberville Road					X				X			

Because watershed size may influence some of these factors, eight of these statistics were adjusted for area by dividing the value by the watershed area in units of 100 acres. These area adjusted statistics are Q_{mean} , Q_{peak} , Q_{50} , Q_{90} , Q_{mean+} , $Q_{mean(ln)}$, $+_{mean}$, and $-_{mean}$. Because environmental statistics are often log-normally distributed, the natural log of seven flow statistics was included in the analyses. These statistics are A , Q_{mean} , Q_{peak} , Q_{90} , $+_{mean}$, $-_{mean}$, and F_{Hd} . Lastly, the natural log of four area-adjusted statistics were included in the analyses; Q_{mean} , Q_{peak} , Q_{90} , $+_{mean}$, and $-_{mean}$. The statistics used for analyses are included in Appendix A. Periods with less than 50% valid flow data were excluded from further analyses of flow relationships.

$T_{Q0.5-yr}$ as suggested by Booth, et al. (2001, 2004) was included in the analyses on a limited basis. This statistic requires several years (>10 years preferably) of sub-daily flow records to compute a meaningful peak flow rate for the 0.5-year event, and this peak must be applied to the sub-daily flow record used to compute $T_{Q0.5-yr}$. Because the sub-daily flow record was limited to the most recent years, $T_{Q0.5-yr}$ was computed for sites with aquatic life scores only. While the aquatic life analysis is complete, correlation with other flow statistics is limited to those data points.

EII Data

Following computation of the flow statistics, both an aquatic life and water quality score were identified for each watershed period based on the available EII data. Since EII sites and flow-gauging locations did not always match (see Figure 1) COA staff with knowledge of both locations determined which EII location (upstream or downstream) would be most representative of the conditions at the gauging station. If both EII sites were considered representative, both were used for analyses.

Table 2: Descriptive flow statistics used for analyses

Hydrologic Variable	Units	Description
A	ac.	The area of the contributing watershed
IC	--	Fraction of the watershed that is impervious
WQ	--	EII water quality score (COA, 2008b)
AQL	--	EII aquatic life score (COA, 2008a)
Q_{peak}	cfs	Peak daily flow rate during the period
Q_{mean}	cfs	Mean daily flow rate during the period
SD	--	The standard deviation of the daily flow rates during the period
COV	--	The average flow during the period divided by the standard deviation (Poff and Ward, 1989)
Q_{50}	cfs	The median daily flow rate or the 50 th percentile
Q_{10}	cfs	The daily flow rate that is exceeded 90 percent of the time during the period, the 10 th percentile.
Q_{90}	cfs	The daily flow rate that is exceeded 10 percent of the time during the period, the 90th percentile.
Q_{mean+}	cfs	The mean of non-zero daily flow rates during the period
$Q_{geommean}$	cfs	The geometric mean of non-zero daily flow rates during the period
$Q_{mean(ln)}$	cfs	The mean of non-zero daily flow rates during the period assuming log-normality
$SD_{(ln)}$	--	The standard deviation of non-zero daily flow rates during the period assuming log-normality
$COV_{(ln)}$	--	The coefficient of variation of non-zero daily flow rates during the period assuming log-normality
$+_{mean}$	cfs	The mean of all positive differences between consecutive daily values, rise rate (Richter et al, 1996)
$-_{mean}$	cfs	The mean of all negative differences between consecutive daily values, fall rate (Richter et al, 1996)
T_{3xQ50}	decimal	the fraction of time during the period that the flow exceeds three times median flow (Clausen and Biggs, 1997)
T_{Qmean}	decimal	The fraction of time during the period that the daily mean flow exceeds the mean flow for the period (Booth, et al., 2001; 2004)
T_{dry}	decimal	The fraction of time during the period that the mean daily flow was less than 0.1 cfs (Ritcher et al., 1996)
$T_{Q0.5-yr}$	decimal	The fraction of time the unit-value flow rate exceeds the peak flow rate of the 6-month storm (Booth, et al., 2001; 2004)
BF_1	decimal	The fraction of flow considered baseflow after one pass with a digital filter
BF_2	decimal	The fraction of flow considered baseflow after two passes with a digital filter
BF_3	decimal	The fraction of flow considered baseflow after three passes with a digital filter
F_{Ld}	days	The average length of time the mean daily flow was below 0.1 cfs for one or more days for the period (Ritcher et al., 1996)
F_{Ln}	--	The average number of times the mean daily flow was below 0.1 cfs for one or days per year during the period (Ritcher et al., 1996)
F_{Hd}	days	The mean duration of high pulses during the period with a high pulse defined as flow greater than the 75 th percentile. (Ritcher et al., 1996)
F_{Hn}	--	The average number of times the mean daily flow was greater than the 75 th percentile flow for one or more days per year during the period. (Ritcher et al., 1996)

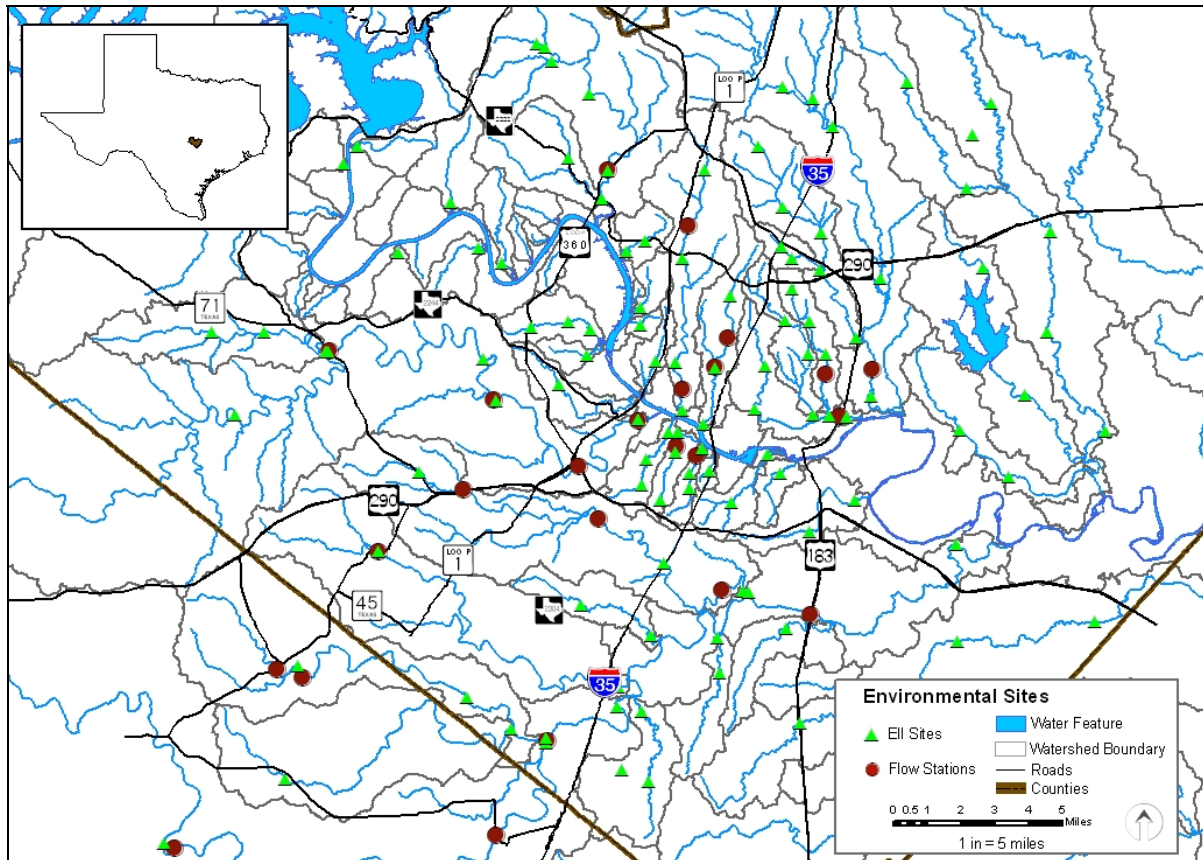


Figure 1: Location map of stream gauging stations and EII sampling points. (Place holder)

The EII scores used for analyses were the average of scores collected during the period. The EII water quality and aquatic life scores are included in Appendix A.

The EII aquatic life score is meant to be an overall reflection of the aquatic health at the sampling location and is a combination of diatom and benthic macroinvertebrate components. The following is an excerpt from the COA Quality Assurance Project Plan (QAPP) explaining the computation of EII aquatic life score (COA, 2008a):

Diatom and benthic macroinvertebrate components are calculated separately, then averaged equally to determine the total Aquatic Life Sub-index score for each site. Metric scores are used to determine the individual component scores as detailed below.

Four metrics are used to determine the diatom aquatic life component: Cymbella Richness, Percent Motile Taxa, Percent Similarity to Reference Sites and Pollution Tolerance Index.

Nine metrics are used to determine the benthic macroinvertebrate aquatic life component: Hilsenhoff Biotic Index, Number of Ephemeroptera Taxa, Number of EPT Taxa, Number of Intolerant Taxa, Number of Taxa, Percent Dominance (Top 3 Taxa), Percent of Total of Chironomidae, Percent of Total as EPT, Percent of Total as Predators. The EII scores for each of these metrics are calculated, then averaged equally by group (diatom, benthic) to yield the total component scores.

The 5th and 95th percentiles for each metric are calculated and extreme values are set to either the 5th or 95th percentile to prevent outliers from determining the range of scores against which sites would be compared. The truncated metrics are converted to EII scores on a 100-point scale using linear interpolation between the 5th (equal to 0) and 95th (equal to 100) percentile values:

$$\text{EII Metric Score} = 100 * (\text{truncated metric} - 5^{\text{th}} \text{ percentile}) / (95^{\text{th}} \text{ percentile} - 5^{\text{th}} \text{ percentile})$$

For one diatom metric (Percent Motile) and three benthic macroinvertebrate metrics (HBI, % Chironomidae, and % Dominance), lower scores imply better conditions. For these metrics, the calculated score is subtracted from 100 to determine the final metric score.

While the EII aquatic life score normally includes both diatom and benthic components averaged together, diatom or benthic scores alone may be used for the aquatic life use score if only one score was available to increase the amount of data.

The EII water quality score is meant to represent a measure of overall ambient water quality (non-storm flow) at the sampling point. The following is an excerpt from the COA Quality Assurance Project Plan (QAPP) explaining the computation of EII water quality score (COA, 2008b):

Scores will be calculated on a 100-point scale using... Measured values will be compared to q-curves for each component of the sub-indices to generate a score from 0 to 100. Weighted component scores will be combined to generate the individual sub-index scores for each site. Values of the six sub-indices for each site will be averaged to generate a total site EII score...

Table a. Q-curve value breakpoints for Water Quality Sub-index parameters.

Parameter	Weight	100	75	50	25	0
<i>E coli</i> (col/100mL)	0.2	1	41	72	490	89460
Conductivity ($\mu\text{S/cm}$)	0.2	0	537	674	796	2330
Nitrate (mg/L)	0.2	0.06	0.10	0.30	0.70	19.5
TSS (mg/L)	0.2	0.5	1.1	1.7	5.7	890
Ammonia (mg/L)	0.1	0.01	0.015	0.020	0.050	2.75
Orthophosphorus (mg/L)	0.1	0.01	0.02	0.05	0.08	3.1

Data Analyses

Two primary data analyses were performed on the data in Appendix A. First, a correlation matrix was constructed using the Pearson correlation coefficient, r . Next, a step-wise regression was performed using SAS (SAS, 2004) to develop a multivariate statistical relationship between the EII aquatic life score and significant hydrologic statistics. Collinearity was examined using tests in SAS as well as the correlation matrix. Since a step-wise regression may not result in the best n -variable model, the regression was performed again using SAS to determine the best n -variable model, using all of the variables, to verify that the step-wise results produced the best n -variable model. Two data points were excluded from the regression analyses as outliers: 08158600 during 1986-92 and 08157500 during 2005-07. Aquatic biologists on staff felt that the sample at 08158600 was not representative while the sample at 08157500 (Waller Creek) was impacted by an outside water source.

Results

Results of the correlation analyses are presented in Appendix B. Correlations greater than 0.80 are in bold; level of significance was not measured in these analyses. (Descriptions of correlation follow those used by Franzblau (1958): high correlation, r 0.80-1.0; marked correlation, r 0.60-0.80; moderate correlation, r 0.40-0.60; low correlation, r 0.20-0.40, no or negligible correlation, r 0.0-0.20.)

EII water quality scores demonstrate high negative correlation with impervious cover (-0.911). This could be a result of how the score is computed using Q-curves and reference sites. Water quality scores are also highly correlated with several measures of flow ($T_{Q_{\text{mean}}}$, BF_1 , BF_2 , F_{Hh} and $\text{Ln}(F_{Hd})$). These statistics are also moderately to highly correlated to impervious cover so there may be confounding influences. While not the primary purpose of this study, it appears that further analyses of the relationships between water quality scores, impervious cover and flow statistics are warranted.

As expected, many of the flow statistics were correlated with impervious cover. Most of the standard flow statistics (peak, mean, standard deviation, etc.) exhibited a low to moderate degree of correlation ($r > \pm 0.50$). Impervious cover was better correlated, negatively, with base flow fractions (BF); as impervious cover increases, base flow fraction decreases. Impervious cover is highly correlated with F_{Hn} meaning that as impervious cover increases the number of high flow occurrences increases. While F_{Hn} increases with impervious cover, F_{Hd} decreases, although the correlation is only marked. Impervious cover was also markedly to highly correlated with $+_{mean}/area$ and $-_{mean}/area$. In general, increasing impervious cover results in decreased base flow fractions, more high-flow events of shorter duration and more rapid rises and falls of the stream flow.

As reported in several studies, many of the flow statistics were correlated with each other. Of the forty-three flow statistics only 12 were not highly correlated with another statistic. Of these 12, all were at least moderately correlated with at least one other statistic; this agrees with the research of Olden and Poff (2003). While principal component analyses were not performed as part of this study, cross-correlations were considered during metric selection.

The aquatic life score was highly negatively correlated only with F_{Ln} but showed moderate correlation to some of the log-transformed statistics. AQL was also moderately negatively correlated with T_{dry} . This is in agreement with Scoggins (2000) and Poff and Ward (1989) that in intermittent systems the main stressor on aquatic life is the absence of flow. When flow is present, other stressors such as flow variability may come into play. F_{Ln} presents an interesting take on the presence/absence of flow; while T_{dry} is the overall fraction of time the stream is dry, F_{Ln} is the average number of dry periods during the year. While the relationship between T_{dry} and F_{Ln} is generally positive (see Figure 2) the variability of the number of dry periods for a given dry fraction may be quite large. It appears that a normally dry creek that maintains prolonged flow during wet periods (a sparsely developed creek) is better for AQL than a creek that has flow several times during the year for shorter periods (a highly urbanized creek). This may be due to the inability of the benthic communities to develop during the rapid wet-dry cycles in the more urban creeks but can develop during the longer wet periods in the less-developed creeks. Further study should include an examination of the individual components of AQL and their relationship to flow statistics.

There are two distinct clusters in these data, one with $AQL < 65$ and another with $AQL > 80$. The creeks with lower AQL scores are generally highly urbanized (Shoal, East Bouldin and Blunn) with many dry-durations during the year and flashy flows while the sites with higher AQL scores tend to be in suburban or rural creeks with few dry-durations but which may be dry for a large portion of the year. Taking all of the data together F_{Ln} has the highest correlation but if the data points with low AQL scores are removed, F_{Ln} has a low correlation and factors associated with flow variability are more important. This leads to the hypothesis that if low flow can be maintained, either as baseflow common in perennial streams or as sustained seasonal flow in rural intermittent streams, flow variability determines the aquatic life but if flow cannot be maintained, as seen in highly urbanized streams, lack of flow dictates the aquatic life.

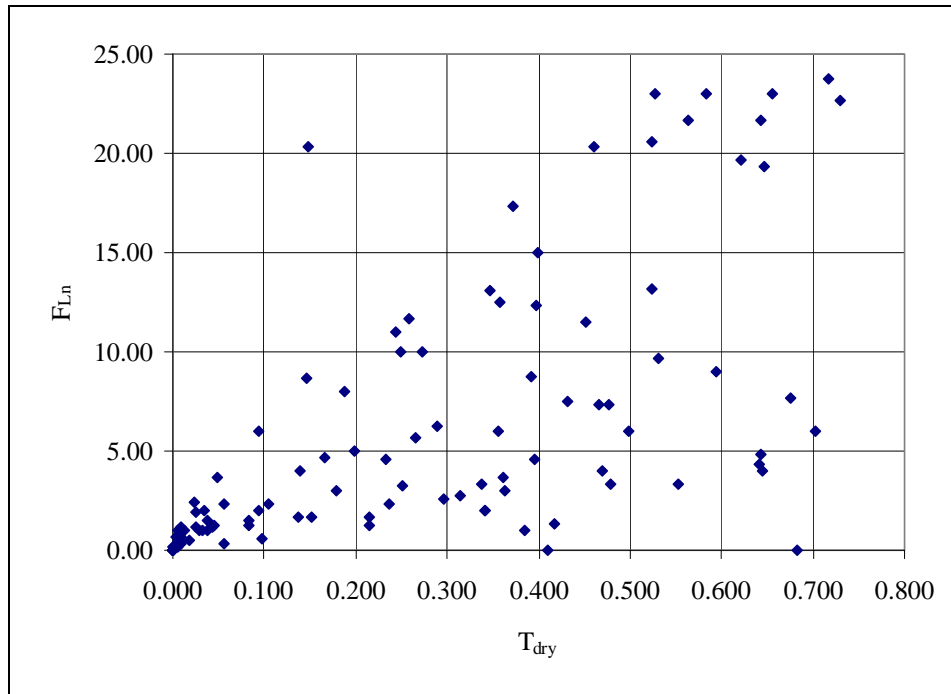


Figure 2. Fraction of the period that is dry versus number of dry durations.

Waller creek may be seen as an example of this along with other Austin-area creeks. While Waller Creek is highly urbanized and does have flashy flows, there is also substantial flow into the creek above the sampling location resulting in virtually no dry-durations and the AQL is generally higher than might be expected. The source of the flow into the creek has yet to be identified but it may be from recharge due to lawn watering or leaking infrastructure. Isotope studies have indicated that much of the baseflow in Waller and other urbanized creeks is coming from the Colorado River (the drinking water source for Austin) rather than natural sources. An implication of this relationship on stormwater controls is that prolonging flow between runoff events can have a significant positive impact on the aquatic health of a stream but that continuous flow is not required in the stream for good aquatic health.

Using the results of this study the impacts on aquatic life related to changes in hydrology caused by new development may be evaluated. Rather than focusing on a single metric, multiple metrics should be evaluated when determining the overall impact of changes on the landscape. Further, these metrics were only related to the impacts on AQL; other metrics such as excess stream power should also be evaluated to examine the impacts on other concerns like erosion.

One of the primary goals of this study was to develop a relationship between AQL and various flow metrics to quantify future aquatic life potential (AQP) using modeled flow. The change in AQP based on current and future values may then be used to prioritize City resources (either monetary or regulatory) in areas with the greatest potential impact. Step-wise regression identified the following model where AQP is the predicted aquatic life score or the aquatic life potential:

$$\text{AQP} = 71.321 - 0.896 F_{Ln} + 3.675 \text{Ln}(Q_{90}) \quad (1)$$

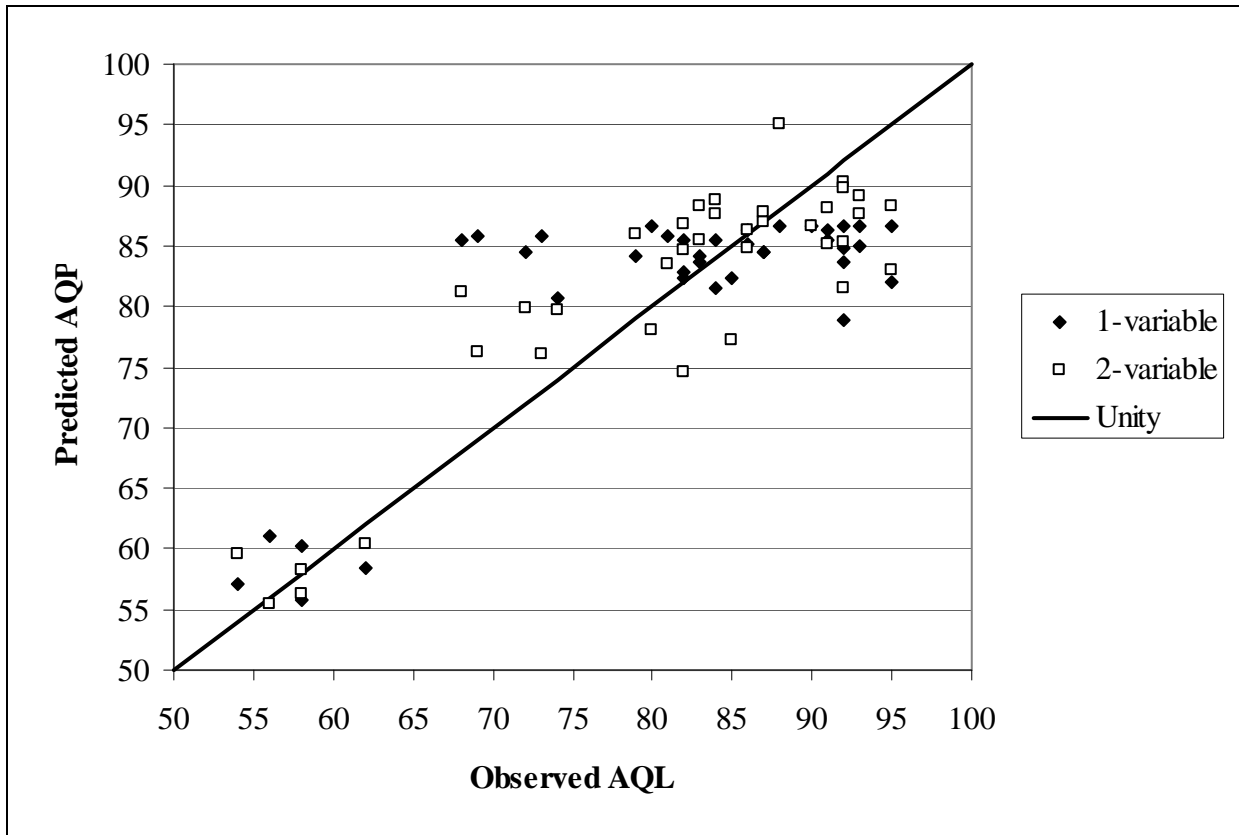


Figure 3. Aquatic life scores (AQL) v. aquatic life potential (AQP) using 1- & 2-variable models

This model includes the two statistics that best correlate with AQL. The wet-dry cycle is represented by F_{Ln} while $\ln(Q_{90})$ addresses flow variability. In addition, $\ln(Q_{90})$ is also highly correlated with $\ln(A)$, which helps address the issue of scaling the model across a wide range of watershed sizes. The adjusted r^2 of Equation 1 is 0.755 and the results when compared with measured AQL are centered on the unity line (see Figure 3). Figure 3 also includes the results if F_{Ln} were used alone to predict AQP ($r^2 = 0.61$). Without the contribution of $\ln(Q_{90})$ many of the subtle variations among different creeks are lost and the predictive power of the relationship is reduced.

While the model presented in Equation 1 is statistically the best fit, it is not be the most useful for predicting aquatic life scores from modeled flows. The City is currently developing continuous simulation models for all watersheds in its planning area using the Soil and Water Assessment Tool (SWAT) (Neitsch et al., 1990). However, the current the SWAT models are not predicting F_{Ln} satisfactorily at this time. As Degasperri et al (2009) also found when using modeled flow, the selected hydrologic metrics must be predicted well by the model. Because AQL is correlated to many of the hydrologic metrics that the SWAT models do predict well, any number of stochastic models may be used to predict AQP that produce results similar to Equation 1. Based on model sensitivity and the ability of existing SWAT models to predict hydrologic metrics, the authors recommend Eqn. 2 be used to predict future AQP. As demonstrated in Figure 2, T_{dry} is correlated to F_{Ln} . Combining BF1 and T_{dry} , which SWAT predicts well, in Eqn 2 acts as a surrogate for F_{Ln} in Eqn. 1. A comparison of Eqn. 1 and 2 are presented in Figure 4.

$$AQP = 63.417 + 3.914 \ln(Q_{90}) + 12.041 BF1 - 18.227 T_{dry} \quad (2)$$

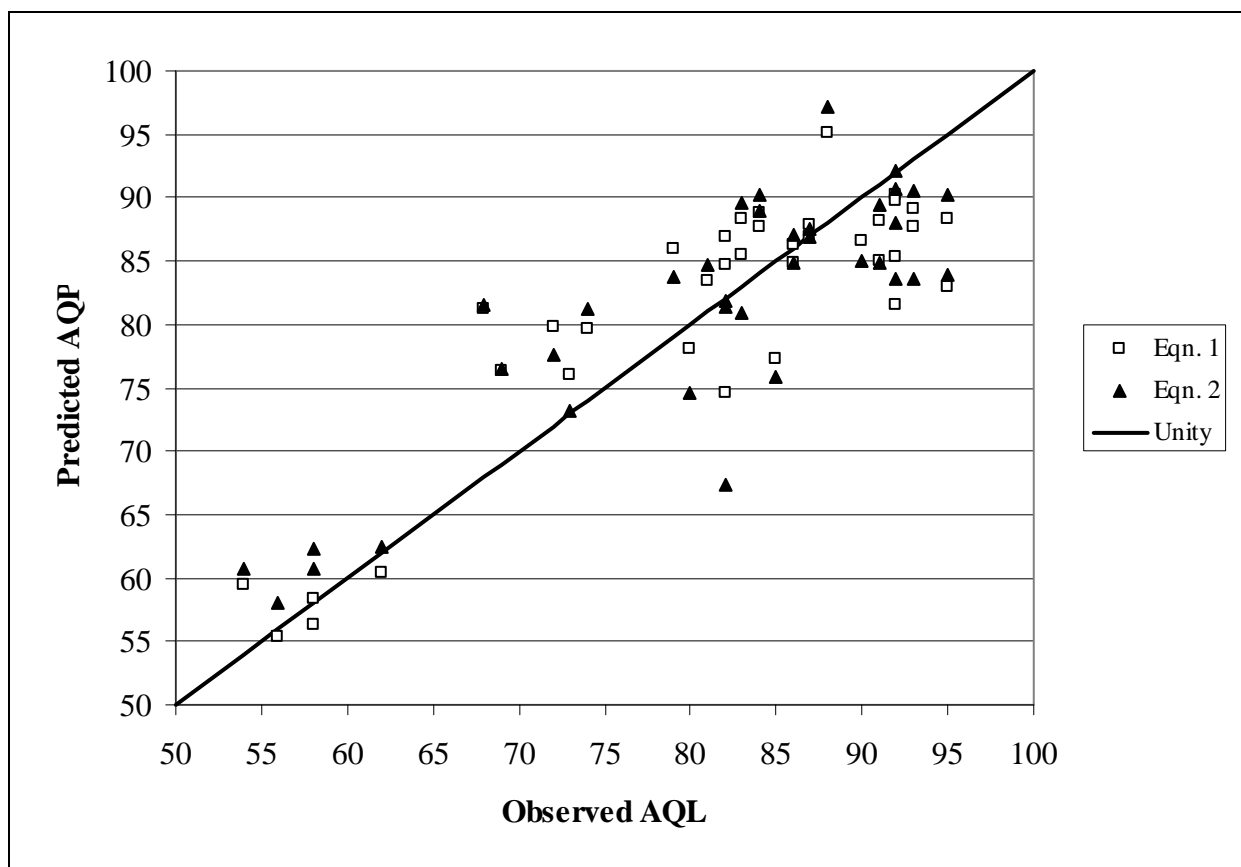


Figure 4. A comparison of Equation 1 and Equation 2

Equation 2 has an adjusted r^2 of 0.702 compared to 0.755 of Equation 1 but is better than the other two variable models and uses variables that are currently predicted well in SWAT. Using Equation 2 to examine pre- and post-development condition can provide insight into the relative differences in aquatic life under different scenarios.

Both models do suffer from one shortcoming: they may be influenced by the size of the watershed through the use of Q_{90} . As the watershed size increases Q_{90} will increase, all other things being equal. This is mitigated to some extent by using the natural log of Q_{90} but comparing AQP from different watersheds or at different locations in a watershed may lead to erroneous conclusions. Comparing AQP under different scenarios at the same location in the watershed is not impacted by this.

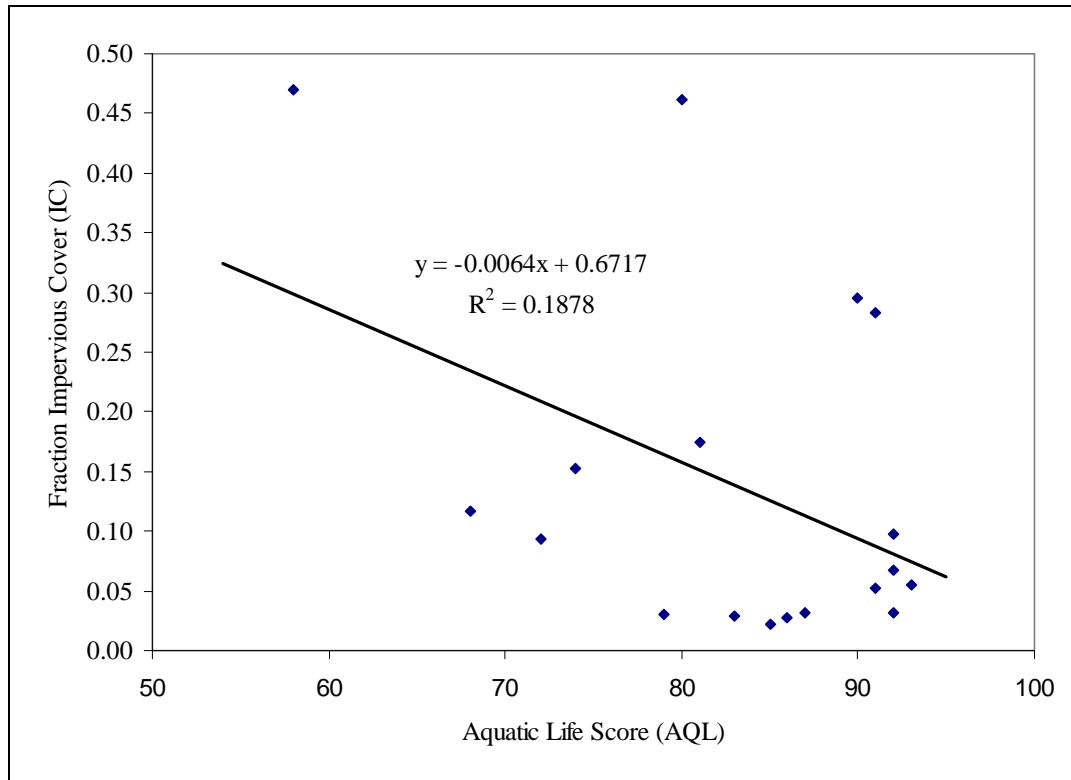


Figure 5. Impervious cover v. aquatic life score

The fraction of drainage area as impervious cover has often been used to measure the degree of urbanization. While that may be appropriate it does not appear to be a good predictor of aquatic life in the creek. Figure 5 is AQL plotted against fraction of impervious cover. While the assumed trend holds, AQL decreases as IC increases, the correlation is weak at best. If impervious cover is included in an assessment of aquatic life in a creek, it should not be used alone without examining the flow regime. Use of impervious cover also does not allow the use of the model for comparing effects of Best Management Practices that may alter flow.

During the course of this study two areas for further study arose with respect to aquatic life and flow statistics. First, the impacts on the various components of AQL should be examined individually. While Equation 1 is a good predictor of aquatic life, individual components may react differently. Second, it would be advantageous to perform these analyses on sub-daily flow data. The finer granularity of sub-daily flow data may reveal heretofore unseen insight into the relationships between aquatic life and hydrology.

Conclusions

The examination of EII water quality scores, EII aquatic life scores, impervious cover and various flow statistics has confirmed some long-held assumptions and revealed new areas for investigation. Water quality scores are highly correlated with impervious cover but impervious cover is not a good indicator of aquatic health in the stream. As noted in other studies, many hydrologic statistics are correlated at some level. Care must be taken when examining hydrologic variables so that collinearity does not produce misleading results. These correlations may be used to evaluate the potential impacts of changes in the watershed to AQL.

Aquatic life scores were related to hydrologic metrics using step-wise regression. The statistical model included two statistics, average number of dry durations per year and the natural log of the 90th percentile flow rate during the period. The adjusted r^2 of the model is 0.755. Because existing City hydrologic models do not predict the average number of dry durations per year well, a second model was developed using the natural log of the 90th percentile flow rate during the period, the fraction of time the creek is dry and one-pass baseflow ratio. The second model has an adjusted r^2 of 0.702. This model will be used to predict future aquatic life potential in creeks in the Austin, Texas, area under different development scenarios using a variety of stormwater controls and to identify the best areas to use City resources.

Neither of these models includes water quality measures. While it currently appears anthropogenic changes in water quality are a secondary concern, with respect to AQL, when compared to changes in hydrology in the Austin area, further refinements to AQP models may include chemical parameter measurements. Other areas of possible concern not encompassed by these models include changes in erosion potential and the impacts of contaminated sediments; these need to be assessed using other means.

This study was prompted by a simple question: “How does one evaluate the impact of future development on aquatic life?” Other studies have attempted to answer this question using data from other hydroclimatic regions, but there was no way of knowing if those results were applicable in the Austin area. This study demonstrated that intermittent streams in semi-arid areas behave differently than perennial streams. The results of this study provide a framework that will allow biologists, hydrologists, engineers and planners to evaluate different scenarios with respect to aquatic life.

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Appendix A – WQ, AQL, IC and flow statistics

Station	Period	% Data	A	IC	WQ	AQL	Rainfall	Q _{peak}	Q _{mean}	SD	COV
08157000	1958-68	100%	1420.3	---	---	---	33.64	188.0	1.81	6.63	3.67
08157500	1958-68	100%	2690.4	---	---	---	33.64	329.0	3.85	13.33	3.46
08158600	1958-68	24%	33114.0	0.042	---	---	33.64	2130.0	20.55	102.75	5.00
08156700	1969-75	11%	4122.6	---	---	---	32.68	131.0	2.82	12.24	4.34
08157000	1969-75	100%	1420.3	---	---	---	32.68	154.0	1.65	6.47	3.93
08157500	1969-75	100%	2690.4	---	---	---	32.68	351.0	3.39	12.51	3.69
08158600	1969-75	100%	33114.0	---	---	---	32.68	2490.0	23.50	103.45	4.40
08158970	1969-75	4%	17527.2	---	---	---	32.68	111.0	3.60	12.53	3.48
08154700	1976-85	75%	14433.5	0.031	---	---	32.44	1170.0	10.11	44.03	4.35
08155200	1976-85	47%	57436.8	0.008	---	---	32.44	3000.0	37.79	158.98	4.21
08155300	1976-85	89%	74647.2	0.015	---	---	32.44	6430.0	38.57	211.53	5.48
08156700	1976-85	87%	4122.6	0.437	---	---	32.44	803.0	3.13	22.39	7.15
08156800	1976-85	28%	7852.7	0.443	---	---	32.44	757.0	5.87	40.92	6.97
08157000	1976-85	48%	1420.3	0.467	---	---	32.44	154.0	1.63	6.18	3.78
08157500	1976-85	48%	2690.4	0.456	---	---	32.44	270.0	3.01	11.15	3.71
08158050	1976-85	89%	8342.8	---	---	---	32.44	1660.0	61.56	275.12	4.47
08158600	1976-85	100%	33114.0	0.139	---	---	32.44	4100.0	25.71	138.89	5.40
08158700	1976-85	65%	79170.6	---	---	---	32.44	2850.0	38.71	126.46	3.27
08158800	1976-85	43%	106419.0	---	---	---	32.44	5400.0	30.54	265.36	8.69
08158810	1976-85	65%	6974.9	0.011	---	---	32.44	915.0	5.90	33.22	5.63
08158840	1976-85	80%	5613.9	---	---	---	32.44	901.0	5.10	27.64	5.42
08158920	1976-85	80%	4011.5	---	---	---	32.44	977.0	4.15	25.82	6.23
08158930	1976-85	10%	11953.5	---	---	---	32.44	487.0	15.67	43.10	2.75
08158970	1976-85	100%	17527.2	0.099	---	---	32.44	3260.0	9.50	80.34	8.45
08159000	1976-85	98%	207310.0	---	---	---	32.44	14500.0	84.80	485.83	5.73
08154700	1986-92	100%	14433.5	0.083	---	---	34.07	1110.0	17.02	58.73	3.45
08155200	1986-92	57%	57436.8	0.012	71	---	35.37	4960.0	60.65	227.83	3.76
08155240	1986-92	57%	68850.1	0.014	69	---	35.29	7000.0	74.59	276.12	3.70
08155300	1986-92	100%	74647.2	0.024	---	---	35.22	10800.0	69.27	377.01	5.44
08156800	1986-92	100%	7852.7	0.455	---	---	34.41	948.0	8.13	37.29	4.59
08157000	1986-92	2%	1420.3	0.467	---	---	34.57	49.3	2.64	7.23	2.74
08158050	1986-92	11%	8342.8	0.376	---	---	35.04	286.0	5.91	32.88	5.56
08158600	1986-92	100%	33114.0	0.222	---	---	34.73	4330.0	39.58	165.83	4.19
08158700	1986-92	100%	79170.6	---	---	---	36.03	5060.0	68.71	217.82	3.17
08158800	1986-92	14%	106419.0	---	---	---	35.81	3230.0	145.35	316.33	2.18
08158810	1986-92	100%	6974.9	0.016	---	---	36.03	1000.0	7.50	31.39	4.18
08158840	1986-92	100%	5613.9	0.041	---	---	35.20	750.0	6.38	32.42	5.08
08158920	1986-92	100%	4011.5	0.088	---	---	34.58	632.0	5.16	25.48	4.94
08158970	1986-92	11%	17527.2	0.142	---	---	34.94	377.0	11.84	39.78	3.36
08159000	1986-92	100%	207310.0	---	---	---	35.49	21900.0	106.98	601.28	5.62
08154700	1993-96	100%	14433.5	0.117	73	68	31.60	794.0	11.38	40.20	3.53
08155200	1993-96	100%	57436.8	0.025	79	---	28.77	1450.0	18.52	55.83	3.01
08155240	1993-96	100%	68850.1	0.027	72	86	28.68	1910.0	24.86	81.54	3.28
08155300	1993-96	100%	74647.2	0.035	---	---	28.64	2980.0	17.45	107.78	6.18
08155400	1993-96	0%	76693.6	---	---	89	28.64	---	---	---	---
08156800	1993-96	100%	7852.7	0.470	47	58	29.95	467.0	7.27	34.90	4.80
08157000	1993-96	59%	1420.3	0.467	---	---	29.27	66.5	1.92	5.63	2.93
08157500	1993-96	50%	2690.4	0.494	53	---	29.14	130.9	4.18	13.53	3.24
08157600	1993-96	0%	778.1	---	---	47	27.97	---	---	---	---
08158050	1993-96	66%	8342.8	0.385	---	---	30.71	750.0	8.60	44.50	5.18
08158600	1993-96	100%	33114.0	0.263	48	51	30.62	2440.0	23.54	97.18	4.13
08158700	1993-96	100%	79170.6	---	---	---	28.42	3400.0	27.48	124.99	4.55
08158800	1993-96	78%	106419.0	---	---	---	28.46	2290.0	9.81	93.00	9.48
08158810	1993-96	100%	6974.9	0.020	---	---	28.42	244.0	2.84	8.74	3.08
08158827	1993-96	0%	---	---	---	81	28.84	---	---	---	---
08158840	1993-96	100%	5613.9	0.052	---	---	28.69	400.0	3.69	18.16	4.92
08158920	1993-96	5%	4011.5	0.113	---	69	28.77	16.0	2.98	3.13	1.05
08159000	1993-96	100%	207310.0	---	---	---	28.60	4800.0	23.27	160.06	6.88
FBU	1993-96	68%	3529.7	---	---	---	28.42	73.4	2.29	4.59	2.00

Appendix A – WQ, AQL, IC and flow statistics (cont.)

Station	Period	% Data	A	IC	WQ	AQL	Rainfall	Q _{peak}	Q _{mean}	SD	COV
08154700	1997-98	100%	14433.5	0.139	71	---	41.97	1180.0	25.80	75.38	2.92
08155200	1997-98	100%	57436.8	0.029	85	83	43.24	3300.0	79.86	207.43	2.60
08155240	1997-98	100%	68850.1	0.031	73	92	42.98	3680.0	105.79	256.86	2.43
08155300	1997-98	100%	74647.2	0.038	74	---	42.09	3780.0	90.94	268.84	2.96
08155400	1997-98	14%	76693.6	---	65	88	42.09	2040.0	347.84	396.23	1.14
08156800	1997-98	100%	7852.7	0.479	---	---	41.47	1030.0	9.45	50.14	5.31
08157500	1997-98	16%	2690.4	0.494	42	---	40.14	186.8	12.25	25.96	2.12
08157600	1997-98	88%	778.1	---	---	---	38.82	110.0	1.56	6.29	4.03
08157700	1997-98	86%	824.1	---	---	---	38.10	96.0	0.93	4.47	4.81
08158050	1997-98	100%	8342.8	0.390	---	---	40.10	1190.0	11.91	57.69	4.84
08158600	1997-98	100%	33114.0	0.283	52	91	39.85	3190.0	43.47	156.38	3.60
08158700	1997-98	100%	79170.6	0.016	78	---	44.06	4100.0	122.50	299.67	2.45
08158810	1997-98	100%	6974.9	0.022	---	---	42.36	800.0	12.61	38.40	3.05
08158840	1997-98	100%	5613.9	0.056	---	---	43.43	570.0	8.83	33.14	3.76
08159000	1997-98	100%	207310.0	---	---	84	42.52	18600.0	178.32	964.95	5.41
FBU	1997-98	96%	3529.7	---	---	---	42.36	169.4	10.30	15.66	1.52
08154700	1999-2001	100%	14433.5	0.153	64	74	28.17	864.0	14.43	42.00	2.91
08155200	1999-2001	100%	57436.8	0.030	74	79	28.93	3140.0	31.31	108.27	3.46
08155240	1999-2001	100%	68850.1	0.032	65	87	29.08	2930.0	37.99	112.95	2.97
08155300	1999-2001	100%	74647.2	0.041	---	---	29.29	2800.0	27.01	104.48	3.87
08155400	1999-2001	100%	76693.6	---	---	82	29.29	2950.0	30.17	115.20	3.82
08156800	1999-2001	100%	7852.7	---	48	54	30.33	1040.0	7.91	42.99	5.43
08157500	1999-2001	97%	2690.4	---	37	73	30.24	414.1	3.87	16.44	4.25
08157600	1999-2001	96%	778.1	---	---	---	32.53	96.7	1.84	6.11	3.31
08157700	1999-2001	99%	824.1	---	---	---	33.05	189.8	2.68	7.70	2.87
08158050	1999-2001	95%	8342.8	---	---	---	30.72	1200.0	9.24	50.07	5.42
08158600	1999-2001	100%	33114.0	---	56	95	30.68	2330.0	34.89	114.39	3.28
08158700	1999-2001	100%	79170.6	0.016	---	---	28.24	3550.0	35.47	126.16	3.56
08158810	1999-2001	100%	6974.9	0.022	---	85	28.92	170.0	4.63	11.91	2.57
08158827	1999-2001	0%	---	---	---	82	29.39	---	---	---	---
08158840	1999-2001	100%	5613.9	0.060	---	---	29.80	151.0	4.29	12.08	2.82
08158930	1999-2001	64%	11953.5	---	---	---	30.06	1230.0	7.47	56.19	7.52
08159000	1999-2001	100%	207310.0	---	---	83	29.67	20300.0	67.39	677.55	10.05
FBU	1999-2001	98%	3529.7	---	---	---	28.92	60.7	4.52	7.27	1.61
08154700	2002-04	100%	14433.5	0.174	68	81	32.42	1120.0	18.99	52.04	2.74
08155200	2002-04	100%	57436.8	0.052	78	91	32.68	6470.0	62.83	284.71	4.53
08155240	2002-04	100%	68850.1	0.055	71	93	32.78	6080.0	73.81	292.06	3.96
08155300	2002-04	100%	74647.2	0.062	72	---	32.77	6250.0	62.51	285.23	4.56
08155400	2002-04	100%	76693.6	---	---	87	33.01	6160.0	77.40	321.98	4.16
08156800	2002-04	100%	7852.7	0.464	49	---	31.88	823.0	8.46	49.52	5.85
08157500	2002-04	87%	2690.4	0.462	43	80	32.25	484.8	5.81	24.49	4.22
08157600	2002-04	93%	778.1	0.403	---	---	32.33	60.2	0.90	4.02	4.47
08157700	2002-04	91%	824.1	0.403	---	---	32.18	95.3	11.40	10.26	0.90
08158600	2002-04	100%	33114.0	0.296	57	90	32.65	2580.0	42.69	150.03	3.51
08158700	2002-04	100%	79170.6	0.067	77	92	32.03	5160.0	85.24	260.43	3.06
08158800	2002-04	0%	106419.0	---	---	77	31.00	---	---	---	---
08158810	2002-04	100%	6974.9	0.094	---	72	32.48	997.0	9.67	46.36	4.80
08158827	2002-04	0%	---	---	---	86	32.87	---	---	---	---
08158840	2002-04	100%	5613.9	0.072	---	---	31.53	640.0	6.09	31.67	5.20
08158920	2002-04	60%	4011.5	0.149	---	---	32.01	287.0	2.83	16.27	5.76
08158930	2002-04	100%	11953.5	---	---	---	32.86	833.0	4.98	43.23	8.69
08159000	2002-04	100%	207310.0	0.097	---	92	30.63	12000.0	121.59	633.40	5.21
FBU	2002-04	100%	3529.7	---	---	---	32.48	177.4	8.65	14.49	1.68
FTB	2002-04	65%	1669.7	---	---	---	30.80	133.4	2.47	10.38	4.19

Appendix A – WQ, AQL, IC and flow statistics (cont.)

Station	Period	% Data	A	IC	WQ	AQL	Rainfall	Q _{peak}	Q _{mean}	SD	COV
08154700	2005-07	100%	14433.5	---	---	92	27.37	364.0	12.88	27.41	2.13
08155200	2005-07	100%	57436.8	---	---	95	27.37	848.0	35.68	81.94	2.30
08155240	2005-07	100%	68850.1	---	---	84	27.37	978.0	41.71	84.75	2.03
08155300	2005-07	100%	74647.2	---	---	---	27.37	1250.0	33.58	90.06	2.68
08155400	2005-07	100%	76693.6	---	---	82	27.37	797.0	27.60	67.94	2.46
08156800	2005-07	100%	7852.7	---	---	62	27.37	560.0	6.69	31.32	4.68
08157500	2005-07	99%	2690.4	---	---	36	27.37	301.2	4.63	15.92	3.44
08157600	2005-07	89%	778.1	---	---	56	27.37	32.0	0.87	3.04	3.48
08157700	2005-07	100%	824.1	---	---	58	27.37	97.1	1.14	4.09	3.58
08158050	2005-07	0%	8342.8	---	---	48	27.37	---	---	---	---
08158600	2005-07	100%	33114.0	---	---	86	27.37	3980.0	42.31	159.56	3.77
08158700	2005-07	100%	79170.6	---	---	93	27.37	1470.0	43.53	99.70	2.29
08158810	2005-07	100%	6974.9	---	---	---	27.37	169.0	5.86	13.65	2.33
08158827	2005-07	0%	---	---	---	86	27.37	---	---	---	---
08158840	2005-07	100%	5613.9	---	---	82	27.37	100.0	3.47	10.85	3.13
08158920	2005-07	100%	4011.5	---	---	---	27.37	86.0	2.36	6.65	2.82
08158930	2005-07	100%	11953.5	---	---	---	27.37	516.0	2.78	19.97	7.19
08158970	2005-07	12%	17527.2	---	---	---	27.37	90.0	2.69	8.98	3.34
08159000	2005-07	100%	207310.0	---	---	---	27.37	6410.0	65.87	267.24	4.06
FBU	2005-07	100%	3529.7	---	---	---	27.34	87.7	8.19	12.05	1.47
FTB	2005-07	96%	1669.7	---	---	---	27.37	250.9	3.96	12.39	3.13

Appendix A – WQ, AQL, IC and flow statistics (cont.)

Station	Period	Q ₅₀	Q ₁₀	Q ₉₀	Q _{mean+}	Q _{gmean}	Q _{mean(ln)}	SD _(ln)	COV _(ln)	+mean	-mean
08157000	1958-68	0.70	0.22	2.0	1.81	0.73	1.20	2.72	1.31	3.36	2.38
08157500	1958-68	1.50	0.80	4.5	3.85	1.79	2.58	2.35	1.04	5.53	4.08
08158600	1958-68	2.30	0.30	37.0	21.98	4.10	17.73	5.54	4.21	32.45	13.63
08156700	1969-75	0.10	0.03	2.8	2.82	0.18	1.12	6.69	6.01	7.65	4.18
08157000	1969-75	0.39	0.18	2.1	1.65	0.48	0.92	3.11	1.62	2.94	1.96
08157500	1969-75	1.10	0.66	4.6	3.39	1.38	2.13	2.54	1.17	4.89	3.84
08158600	1969-75	6.60	0.89	38.0	23.89	6.35	20.57	4.63	3.08	45.68	17.71
08158970	1969-75	1.60	1.10	2.0	3.60	1.71	2.21	2.04	0.81	7.48	4.99
08154700	1976-85	3.40	0.25	18.0	10.21	2.83	10.79	5.14	3.68	17.06	5.52
08155200	1976-85	5.40	0.08	73.0	40.72	5.27	68.10	9.61	12.90	48.44	15.59
08155300	1976-85	0.00	0.00	94.0	106.07	25.79	197.06	7.51	7.58	140.45	36.84
08156700	1976-85	0.14	0.02	2.9	3.31	0.23	1.34	6.48	5.65	8.26	5.12
08156800	1976-85	0.00	0.00	3.0	15.22	1.22	13.15	8.87	10.77	29.59	12.40
08157000	1976-85	0.43	0.14	2.1	1.63	0.49	0.97	3.22	1.71	2.81	2.02
08157500	1976-85	0.75	0.42	4.3	3.01	1.00	1.74	2.87	1.43	4.66	3.41
08158050	1976-85	0.28	0.00	16.5	71.30	0.64	22.92	14.53	35.88	18.77	11.05
08158600	1976-85	6.80	0.93	34.0	25.88	6.42	22.89	4.93	3.42	56.63	21.33
08158700	1976-85	10.00	1.30	97.0	39.21	10.81	42.73	5.25	3.83	33.59	14.26
08158800	1976-85	0.00	0.00	3.6	76.87	1.88	36.22	11.40	19.28	134.77	43.49
08158810	1976-85	1.70	0.11	11.0	6.30	1.82	5.71	4.54	2.97	7.53	2.37
08158840	1976-85	0.59	0.00	9.8	6.09	0.82	8.15	8.53	9.89	11.92	3.70
08158920	1976-85	0.28	0.00	7.5	6.71	1.29	7.03	6.29	5.34	9.87	4.29
08158930	1976-85	6.30	4.10	22.0	15.67	7.69	11.06	2.34	1.03	41.39	20.49
08158970	1976-85	2.10	0.52	12.0	9.50	2.35	5.64	3.76	2.19	15.37	11.10
08159000	1976-85	8.80	1.00	148.0	87.35	12.99	63.81	5.96	4.81	146.48	51.87
08154700	1986-92	4.70	0.44	32.0	17.07	4.09	17.81	5.56	4.24	20.25	8.38
08155200	1986-92	5.80	0.04	139.0	64.72	4.21	284.05	18.21	67.44	75.92	23.92
08155240	1986-92	7.10	0.28	175.0	74.59	6.96	129.04	11.21	18.52	71.14	26.47
08155300	1986-92	0.00	0.00	122.0	158.15	18.55	836.74	15.80	45.09	208.78	61.61
08156800	1986-92	0.06	0.00	14.0	14.36	1.49	21.74	10.14	14.60	32.11	13.66
08157000	1986-92	0.63	0.61	3.7	2.64	0.98	1.63	2.75	1.34	4.30	3.95
08158050	1986-92	0.13	0.00	1.5	7.20	0.29	1.62	6.38	5.49	20.29	10.44
08158600	1986-92	9.20	2.10	66.0	39.75	10.91	28.26	3.97	2.39	75.96	31.82
08158700	1986-92	10.00	0.32	157.0	68.71	9.21	126.07	9.85	13.65	54.15	21.52
08158800	1986-92	0.91	0.00	403.0	238.55	39.63	4111.45	21.05	103.73	265.00	65.18
08158810	1986-92	1.10	0.00	17.0	8.98	1.40	18.62	9.74	13.31	9.86	3.35
08158840	1986-92	0.29	0.00	12.0	9.49	1.24	11.02	8.09	8.83	16.04	5.48
08158920	1986-92	0.04	0.00	9.0	9.54	1.32	14.04	8.81	10.61	15.30	6.29
08158970	1986-92	4.50	0.29	12.0	11.84	2.83	13.30	5.80	4.58	18.02	10.16
08159000	1986-92	5.40	0.00	199.0	136.84	13.52	180.75	9.75	13.33	186.44	66.09
08154700	1993-96	3.90	0.39	22.0	11.55	3.78	13.24	4.87	3.36	16.28	5.22
08155200	1993-96	0.71	0.00	52.0	21.84	2.49	69.27	13.19	27.82	14.48	5.80
08155240	1993-96	1.90	0.20	62.0	25.12	3.24	37.14	9.10	11.42	14.99	6.20
08155300	1993-96	0.00	0.00	40.0	58.21	21.70	64.76	4.39	2.81	64.41	21.61
08155400	1993-96	---	---	---	---	---	---	---	---	---	---
08156800	1993-96	0.00	0.00	8.8	19.27	1.28	69.65	16.89	54.37	38.31	17.53
08157000	1993-96	0.59	0.42	1.7	1.92	0.75	1.16	2.53	1.17	2.91	2.09
08157500	1993-96	0.89	0.50	5.5	4.18	1.21	2.24	3.03	1.55	6.70	4.21
08157600	1993-96	---	---	---	---	---	---	---	---	---	---
08158050	1993-96	0.18	0.00	8.2	13.18	0.80	9.99	9.46	12.44	31.54	13.88
08158600	1993-96	7.00	1.40	35.0	23.77	7.77	20.61	4.04	2.46	51.47	19.48
08158700	1993-96	4.00	0.15	62.0	28.34	4.27	56.40	9.70	13.19	19.23	9.61
08158800	1993-96	0.00	0.00	0.5	27.80	0.59	8.30	9.96	14.01	73.47	19.05
08158810	1993-96	0.11	0.00	7.8	3.50	0.52	7.31	10.00	14.13	3.06	1.17
08158827	1993-96	---	---	---	---	---	---	---	---	---	---
08158840	1993-96	0.00	0.00	7.1	9.79	2.94	12.61	5.51	4.17	10.84	3.82
08158920	1993-96	2.60	0.07	5.6	3.12	1.66	4.57	4.15	2.56	1.98	0.79
08159000	1993-96	1.80	0.00	31.0	32.01	4.57	28.31	6.76	6.12	57.61	22.09
FBU	1993-96	0.48	0.00	7.1	3.03	0.55	22.04	15.17	40.36	0.65	0.56

Appendix A – WQ, AQL, IC and flow statistics (cont.)

Station	Period	Q ₅₀	Q ₁₀	Q ₉₀	Q _{mean+}	Q _{geomean}	Q _{mean(ln)}	SD _(ln)	COV _(ln)	+ _{mean}	- _{mean}
08154700	1997-98	12.00	0.42	46.5	25.94	7.35	43.27	6.58	5.81	37.22	9.75
08155200	1997-98	18.50	0.11	182.0	83.65	10.23	414.13	15.19	40.48	86.14	27.34
08155240	1997-98	31.50	0.14	241.5	111.93	19.41	379.53	11.46	19.53	131.08	31.29
08155300	1997-98	5.10	0.00	214.5	170.22	59.97	272.82	5.70	4.44	224.70	53.64
08155400	1997-98	297.00	0.57	708.0	347.84	75.18	3655.57	16.23	48.61	226.69	40.78
08156800	1997-98	0.06	0.00	14.0	17.12	1.28	24.73	11.41	19.33	36.04	16.21
08157500	1997-98	2.08	0.98	36.2	12.25	3.69	9.73	4.03	2.44	22.96	11.04
08157600	1997-98	0.25	0.02	2.4	1.61	0.29	1.20	5.41	4.03	3.68	1.80
08157700	1997-98	0.18	0.00	1.9	1.06	0.23	0.87	5.15	3.70	1.40	1.05
08158050	1997-98	0.79	0.00	21.0	15.12	1.77	10.01	6.43	5.56	29.28	15.94
08158600	1997-98	18.00	1.40	62.0	43.47	13.12	47.27	4.96	3.46	80.99	27.45
08158700	1997-98	44.50	2.45	277.0	122.50	30.67	167.35	6.31	5.36	109.23	35.29
08158810	1997-98	3.70	0.02	29.0	13.93	3.13	25.14	7.70	7.98	16.22	5.26
08158840	1997-98	1.50	0.00	23.0	13.31	3.97	14.80	5.07	3.59	18.57	5.54
08159000	1997-98	9.55	0.00	332.5	204.36	19.75	247.48	9.48	12.49	306.90	98.79
FBU	1997-98	5.91	0.24	25.4	10.39	3.20	19.93	6.77	6.14	3.41	2.05
08154700	1999-2001	3.30	0.03	34.0	15.56	3.03	33.89	9.00	11.12	14.77	6.23
08155200	1999-2001	3.00	0.00	97.0	45.20	9.02	134.65	10.23	14.89	38.92	10.69
08155240	1999-2001	4.90	0.02	119.0	40.66	5.16	141.42	13.11	27.38	33.11	10.48
08155300	1999-2001	0.00	0.00	94.0	79.58	21.97	353.91	10.57	16.08	66.98	21.83
08155400	1999-2001	1.10	0.00	100.0	47.31	5.93	77.75	9.67	13.07	50.32	16.82
08156800	1999-2001	0.00	0.00	9.5	21.10	0.89	84.61	20.48	95.46	42.53	21.04
08157500	1999-2001	0.84	0.34	5.2	3.87	1.06	2.22	3.37	1.83	6.24	4.06
08157600	1999-2001	0.31	0.01	3.4	2.03	0.46	1.78	5.17	3.72	2.97	1.88
08157700	1999-2001	0.25	0.00	7.3	3.62	0.70	6.57	8.27	9.26	2.95	1.65
08158050	1999-2001	0.43	0.00	9.8	14.35	1.60	10.98	7.12	6.79	29.11	14.16
08158600	1999-2001	8.90	0.58	65.0	36.14	8.61	41.37	5.88	4.70	49.00	23.65
08158700	1999-2001	4.60	0.20	102.0	37.03	4.69	86.61	11.19	18.44	39.39	11.80
08158810	1999-2001	0.69	0.00	13.0	5.68	1.04	10.72	8.69	10.29	5.64	1.63
08158827	1999-2001	---	---	---	---	---	---	---	---	---	---
08158840	1999-2001	0.26	0.00	15.0	7.53	1.66	10.06	6.68	5.99	6.94	2.21
08158930	1999-2001	0.14	0.00	4.3	10.77	0.46	4.06	8.03	8.70	28.91	11.85
08159000	1999-2001	5.30	0.00	94.0	87.82	11.55	61.93	6.25	5.27	178.55	66.88
FBU	1999-2001	0.57	0.00	12.1	5.96	2.03	10.28	6.05	4.95	1.26	0.81
08154700	2002-04	7.85	1.20	37.0	18.99	6.75	20.53	4.44	2.87	27.00	7.54
08155200	2002-04	13.00	0.82	120.0	62.94	11.66	75.30	6.90	6.38	82.65	25.03
08155240	2002-04	21.00	1.00	147.0	73.81	15.30	100.77	6.97	6.51	80.98	24.90
08155300	2002-04	0.55	0.00	133.0	116.32	26.36	261.44	8.52	9.87	156.49	38.54
08155400	2002-04	3.70	0.03	149.0	83.91	6.70	122.36	11.14	18.23	95.90	28.97
08156800	2002-04	0.07	0.00	6.4	12.70	0.40	6.62	10.74	16.71	38.73	15.89
08157500	2002-04	1.25	0.56	7.5	5.81	1.65	3.15	3.12	1.63	9.77	6.26
08157600	2002-04	0.05	0.00	1.0	1.46	0.21	1.41	7.06	6.67	2.03	1.81
08157700	2002-04	12.14	0.06	21.8	11.40	2.90	69.58	12.43	23.93	5.36	2.72
08158600	2002-04	12.00	2.00	74.0	42.69	12.27	34.59	4.22	2.64	92.06	30.46
08158700	2002-04	21.00	0.28	195.0	85.24	15.56	198.69	9.55	12.73	94.74	28.33
08158800	2002-04	---	---	---	---	---	---	---	---	---	---
08158810	2002-04	1.50	0.00	18.0	11.73	2.40	14.03	6.54	5.75	20.73	5.73
08158827	2002-04	---	---	---	---	---	---	---	---	---	---
08158840	2002-04	0.56	0.00	12.0	8.54	1.43	9.64	7.05	6.65	17.45	4.14
08158920	2002-04	0.15	0.00	3.7	4.91	1.12	4.22	5.09	3.63	7.64	3.07
08158930	2002-04	0.04	0.00	2.4	8.80	0.27	2.85	8.75	10.45	22.47	10.71
08159000	2002-04	9.75	0.12	208.0	128.39	9.84	218.23	12.06	22.15	215.60	64.39
FBU	2002-04	6.58	0.08	20.7	8.71	1.91	25.55	9.76	13.36	2.81	1.48
FTB	2002-04	0.40	0.03	2.6	2.59	0.39	1.97	6.08	5.00	3.95	3.49

Appendix A – WQ, AQL, IC and flow statistics (cont.)

Station	Period	Q ₅₀	Q ₁₀	Q ₉₀	Q _{mean+}	Q _{geomean}	Q _{mean(ln)}	SD _(ln)	COV _(ln)	+mean	-mean
08154700	2005-07	3.40	0.36	33.0	13.20	3.82	17.42	5.71	4.45	12.52	4.75
08155200	2005-07	2.50	0.50	116.0	35.68	4.74	43.49	8.21	9.13	23.00	10.89
08155240	2005-07	6.10	0.54	124.0	41.71	6.85	73.43	8.83	10.67	26.43	10.54
08155300	2005-07	0.00	0.00	102.0	89.25	30.14	322.24	8.82	10.65	80.25	25.06
08155400	2005-07	1.60	0.00	88.0	41.17	6.69	102.26	10.33	15.25	34.78	13.08
08156800	2005-07	0.00	0.00	9.4	14.67	0.91	24.39	12.97	26.65	30.53	15.01
08157500	2005-07	1.02	0.42	7.6	4.63	1.34	2.81	3.38	1.85	7.38	4.76
08157600	2005-07	0.00	0.00	1.6	1.73	0.41	1.92	5.80	4.57	2.21	1.47
08157700	2005-07	0.12	0.00	2.3	1.43	0.27	1.50	6.37	5.46	2.25	1.20
08158050	2005-07	---	---	---	---	---	---	---	---	---	---
08158600	2005-07	8.50	1.60	74.0	42.58	10.20	35.77	4.87	3.36	76.96	32.50
08158700	2005-07	2.30	0.00	133.0	68.69	11.12	456.41	15.27	41.03	48.00	17.05
08158810	2005-07	0.73	0.00	15.0	8.47	2.37	13.51	6.45	5.60	6.81	2.32
08158827	2005-07	---	---	---	---	---	---	---	---	---	---
08158840	2005-07	0.00	0.00	6.5	7.02	1.61	9.97	6.74	6.10	6.20	2.07
08158920	2005-07	0.06	0.00	6.2	4.38	1.12	6.81	6.68	5.99	5.11	1.95
08158930	2005-07	0.00	0.00	1.9	5.60	0.33	3.54	8.87	10.79	12.73	5.51
08158970	2005-07	0.81	0.47	3.9	2.69	1.10	1.80	2.69	1.29	3.55	2.18
08159000	2005-07	5.10	0.00	171.0	81.14	10.30	129.38	9.48	12.52	124.73	42.81
FBU	2005-07	2.14	0.02	23.7	8.99	2.44	17.82	7.35	7.24	2.17	1.21
FTB	2005-07	0.54	0.06	11.3	3.96	0.55	8.14	10.21	14.82	4.35	3.54

Appendix A – WQ, AQL, IC and flow statistics (cont.)

Station	Period	T _{3XQ50}	T _{qmean}	T _{drv}	T _{Q0.5-vr}	BF ₁	BF ₂	BF ₃	F _{Ld}	F _{Ln}	F _{Hd}	F _{Hn}
08157000	1958-68	0.094	0.105	0.001	---	0.38	0.29	0.26	1.50	0.18	2.90	30.36
08157500	1958-68	0.099	0.113	0.000	---	0.42	0.34	0.31	0.00	0.00	2.93	31.00
08158600	1958-68	0.359	0.200	0.071	---	0.49	0.34	0.28	16.75	0.36	7.16	2.91
08156700	1969-75	0.301	0.100	0.480	---	0.14	0.05	0.03	5.83	3.29	2.62	3.71
08157000	1969-75	0.141	0.118	0.008	---	0.27	0.18	0.16	2.63	1.14	2.50	36.00
08157500	1969-75	0.120	0.120	0.000	---	0.35	0.27	0.24	0.00	0.00	2.38	34.71
08158600	1969-75	0.235	0.190	0.026	---	0.47	0.33	0.28	8.25	1.14	6.28	14.29
08158970	1969-75	0.054	0.054	0.000	---	0.41	0.33	0.29	0.00	0.00	1.88	1.14
08154700	1976-85	0.199	0.199	0.043	---	0.57	0.41	0.34	9.83	1.20	9.29	7.30
08155200	1976-85	0.350	0.176	0.103	---	0.60	0.42	0.33	14.75	1.20	12.45	3.30
08155300	1976-85	0.364	0.180	0.644	---	0.53	0.33	0.24	43.67	4.80	16.81	4.80
08156700	1976-85	0.290	0.098	0.373	---	0.16	0.07	0.04	6.88	17.30	3.14	25.30
08156800	1976-85	0.386	0.076	0.665	---	0.16	0.05	0.03	14.78	4.60	5.57	4.60
08157000	1976-85	0.128	0.116	0.024	---	0.28	0.19	0.18	4.30	1.00	2.65	16.50
08157500	1976-85	0.141	0.119	0.000	---	0.30	0.21	0.20	0.00	0.00	2.55	15.80
08158050	1976-85	0.302	0.064	0.347	---	0.07	0.03	0.02	8.60	13.10	3.74	21.40
08158600	1976-85	0.201	0.148	0.025	---	0.42	0.29	0.24	4.89	1.90	4.63	19.40
08158700	1976-85	0.267	0.221	0.018	---	0.52	0.35	0.25	8.60	0.50	18.56	3.20
08158800	1976-85	0.397	0.064	0.636	---	0.39	0.16	0.08	29.91	3.30	14.41	2.70
08158810	1976-85	0.231	0.206	0.097	---	0.61	0.44	0.35	38.17	0.60	14.39	4.10
08158840	1976-85	0.320	0.158	0.297	---	0.49	0.31	0.23	33.19	2.60	12.69	5.40
08158920	1976-85	0.389	0.162	0.432	---	0.42	0.24	0.17	16.79	7.50	6.42	11.10
08158930	1976-85	0.112	0.126	0.000	---	0.44	0.37	0.34	0.00	0.00	2.29	3.40
08158970	1976-85	0.200	0.135	0.007	---	0.38	0.26	0.22	3.25	0.80	5.27	17.10
08159000	1976-85	0.300	0.158	0.033	---	0.48	0.29	0.22	11.70	1.00	9.09	9.80
08154700	1986-92	0.213	0.183	0.024	---	0.56	0.39	0.31	3.59	2.43	9.90	8.86
08155200	1986-92	0.339	0.194	0.214	---	0.63	0.47	0.38	34.78	1.29	17.33	3.00
08155240	1986-92	0.352	0.208	0.005	---	0.62	0.45	0.36	8.00	0.14	20.28	2.57
08155300	1986-92	0.438	0.165	0.593	---	0.49	0.30	0.21	24.08	9.00	19.72	4.57
08156800	1986-92	0.453	0.137	0.523	---	0.20	0.08	0.05	9.28	20.57	3.31	27.57
08157000	1986-92	0.129	0.129	0.000	---	0.29	0.23	0.20	0.00	0.00	2.00	1.14
08158050	1986-92	0.231	0.066	0.381	---	0.11	0.03	0.02	8.00	1.86	2.76	3.57
08158600	1986-92	0.214	0.160	0.006	---	0.42	0.29	0.24	5.00	0.43	4.33	20.43
08158700	1986-92	0.344	0.218	0.007	---	0.66	0.49	0.39	6.33	0.43	18.74	4.86
08158800	1986-92	0.478	0.292	0.426	---	0.64	0.44	0.35	78.00	0.29	11.38	1.14
08158810	1986-92	0.323	0.211	0.314	---	0.65	0.47	0.38	42.32	2.71	26.63	3.43
08158840	1986-92	0.362	0.164	0.395	---	0.47	0.29	0.22	31.56	4.57	23.56	3.86
08158920	1986-92	0.462	0.160	0.523	---	0.38	0.22	0.15	14.53	13.14	7.03	12.86
08158970	1986-92	0.066	0.176	0.022	---	0.44	0.34	0.31	3.00	0.29	3.43	2.00
08159000	1986-92	0.363	0.152	0.233	---	0.50	0.32	0.24	18.66	4.57	9.28	9.71
08154700	1993-96	0.253	0.253	0.038	0.0007	0.56	0.40	0.33	13.75	1.00	7.23	11.75
08155200	1993-96	0.431	0.290	0.252	---	0.71	0.56	0.47	28.31	3.25	20.71	4.25
08155240	1993-96	0.377	0.260	0.045	0.0011	0.69	0.53	0.44	13.20	1.25	30.42	3.00
08155300	1993-96	0.300	0.196	0.702	---	0.55	0.35	0.26	42.75	6.00	30.33	3.00
08155400	1993-96	---	---	---	---	---	---	---	---	---	---	---
08156800	1993-96	0.377	0.111	0.717	0.0003	0.15	0.03	0.01	11.03	23.75	3.96	23.00
08157000	1993-96	0.101	0.101	0.000	---	0.34	0.27	0.26	0.00	0.00	2.30	23.25
08157500	1993-96	0.142	0.114	0.000	---	0.27	0.19	0.17	0.00	0.00	2.28	20.00
08157600	1993-96	---	---	---	---	---	---	---	---	---	---	---
08158050	1993-96	0.367	0.098	0.451	---	0.15	0.04	0.02	9.48	11.50	3.46	17.50
08158600	1993-96	0.219	0.179	0.013	0.0006	0.44	0.33	0.28	4.75	1.00	3.93	22.25
08158700	1993-96	0.338	0.249	0.083	---	0.68	0.52	0.44	24.20	1.25	28.00	3.25
08158800	1993-96	0.353	0.051	0.682	---	0.34	0.12	0.06	96.88	2.00	17.38	4.00
08158810	1993-96	0.444	0.268	0.498	---	0.71	0.55	0.45	30.33	6.00	28.15	3.25
08158827	1993-96	---	---	---	---	---	---	---	---	---	---	---
08158840	1993-96	0.377	0.187	0.645	---	0.55	0.36	0.28	58.88	4.00	25.85	3.25
08158920	1993-96	0.075	0.373	0.090	---	0.66	0.51	0.36	2.00	0.75	5.67	0.75
08159000	1993-96	0.342	0.131	0.289	---	0.38	0.21	0.16	16.88	6.25	6.85	13.25
FBU	1993-96	0.305	0.298	0.392	---	0.81	0.70	0.63	11.09	8.75	20.67	3.00

Appendix A – WQ, AQL, IC and flow statistics (cont.)

Station	Period	T _{3XQ50}	T _{qmean}	T _{dry}	T _{Q0.5-yr}	BF ₁	BF ₂	BF ₃	F _{Ld}	F _{Ln}	F _{Hd}	F _{Hn}
08154700	1997-98	0.142	0.244	0.038	---	0.56	0.40	0.33	9.33	1.50	7.42	12.00
08155200	1997-98	0.356	0.271	0.095	0.0197	0.62	0.45	0.36	17.25	2.00	10.71	8.50
08155240	1997-98	0.286	0.270	0.084	0.0090	0.61	0.44	0.35	20.33	1.50	15.25	6.00
08155300	1997-98	0.447	0.237	0.470	---	0.55	0.35	0.27	42.88	4.00	15.17	6.00
08155400	1997-98	0.081	0.424	0.020	---	0.70	0.52	0.39	2.00	0.50	8.33	1.50
08156800	1997-98	0.437	0.126	0.527	---	0.16	0.04	0.02	8.37	23.00	3.31	27.50
08157500	1997-98	0.270	0.209	0.000	---	0.23	0.12	0.10	0.00	0.00	1.53	9.50
08157600	1997-98	0.206	0.141	0.248	---	0.28	0.17	0.14	7.95	10.00	3.36	23.50
08157700	1997-98	0.237	0.166	0.358	---	0.35	0.20	0.15	8.96	12.50	3.48	22.00
08158050	1997-98	0.284	0.129	0.244	---	0.18	0.07	0.05	8.09	11.00	3.37	27.00
08158600	1997-98	0.130	0.167	0.005	0.0006	0.45	0.32	0.27	2.00	1.00	4.39	20.50
08158700	1997-98	0.249	0.266	0.000	---	0.65	0.47	0.38	0.00	0.00	10.17	9.00
08158810	1997-98	0.285	0.270	0.179	---	0.63	0.46	0.37	21.83	3.00	12.69	6.50
08158840	1997-98	0.263	0.225	0.356	---	0.54	0.36	0.28	21.67	6.00	18.20	5.00
08159000	1997-98	0.373	0.171	0.138	0.0068	0.44	0.26	0.19	12.63	4.00	8.71	10.50
FBU	1997-98	0.199	0.311	0.034	---	0.72	0.58	0.48	4.33	3.00	3.80	23.00
08154700	1999-2001	0.307	0.250	0.166	0.0008	0.59	0.43	0.35	13.00	4.67	10.15	9.00
08155200	1999-2001	0.366	0.259	0.341	0.0015	0.72	0.61	0.52	62.33	2.00	24.91	3.67
08155240	1999-2001	0.339	0.255	0.151	0.0004	0.68	0.54	0.44	33.20	1.67	20.77	4.33
08155300	1999-2001	0.339	0.208	0.676	---	0.60	0.44	0.34	32.22	7.67	22.75	4.00
08155400	1999-2001	0.307	0.193	0.385	0.0010	0.58	0.40	0.31	140.67	1.00	17.13	5.33
08156800	1999-2001	0.375	0.108	0.729	0.0003	0.15	0.03	0.01	11.75	22.67	3.91	23.00
08157500	1999-2001	0.146	0.115	0.004	0.0002	0.28	0.19	0.17	2.00	0.67	2.81	31.67
08157600	1999-2001	0.257	0.182	0.188	---	0.35	0.24	0.20	8.25	8.00	3.42	25.67
08157700	1999-2001	0.392	0.234	0.399	---	0.59	0.48	0.37	9.64	15.00	5.23	17.33
08158050	1999-2001	0.327	0.104	0.397	---	0.20	0.08	0.05	11.14	12.33	3.72	22.67
08158600	1999-2001	0.237	0.182	0.049	0.0006	0.42	0.27	0.21	4.91	3.67	4.47	19.67
08158700	1999-2001	0.380	0.259	0.057	---	0.70	0.55	0.46	62.00	0.33	30.44	3.00
08158810	1999-2001	0.311	0.223	0.338	0.0025	0.71	0.57	0.48	37.00	3.33	22.33	4.00
08158827	1999-2001	---	---	---	---	---	---	---	---	---	---	---
08158840	1999-2001	0.348	0.184	0.479	---	0.59	0.42	0.32	52.50	3.33	54.40	1.67
08158930	1999-2001	0.259	0.083	0.410	---	0.16	0.05	0.03	14.40	6.67	3.83	15.33
08159000	1999-2001	0.344	0.136	0.236	0.0016	0.34	0.19	0.14	37.00	2.33	6.23	14.67
FBU	1999-2001	0.472	0.318	0.265	---	0.75	0.61	0.50	16.71	5.67	7.85	11.33
08154700	2002-04	0.182	0.245	0.008	0.0010	0.60	0.42	0.34	4.50	0.67	6.87	13.00
08155200	2002-04	0.313	0.215	0.005	0.0164	0.61	0.40	0.31	5.00	0.33	16.06	5.67
08155240	2002-04	0.261	0.227	0.000	0.0046	0.63	0.43	0.34	0.00	0.00	13.60	6.67
08155300	2002-04	0.487	0.200	0.476	---	0.56	0.34	0.24	23.73	7.33	16.12	5.67
08155400	2002-04	0.348	0.163	0.137	0.0107	0.53	0.30	0.20	30.00	1.67	17.13	5.33
08156800	2002-04	0.345	0.089	0.563	---	0.13	0.03	0.01	9.49	21.67	3.97	23.00
08157500	2002-04	0.157	0.119	0.000	0.0003	0.27	0.18	0.16	0.00	0.00	2.70	29.67
08157600	2002-04	0.390	0.115	0.584	---	0.19	0.12	0.09	8.67	23.00	3.46	24.67
08157700	2002-04	0.016	0.540	0.272	---	0.75	0.63	0.55	9.07	10.00	6.94	12.00
08158600	2002-04	0.189	0.170	0.000	0.0012	0.40	0.25	0.20	0.00	0.00	3.97	22.33
08158700	2002-04	0.344	0.266	0.000	0.0054	0.67	0.49	0.40	0.00	0.00	17.00	5.33
08158800	2002-04	---	---	---	---	---	---	---	---	---	---	---
08158810	2002-04	0.328	0.213	0.215	0.0071	0.57	0.38	0.29	47.20	1.67	30.44	3.00
08158827	2002-04	---	---	---	---	---	---	---	---	---	---	---
08158840	2002-04	0.352	0.154	0.360	---	0.52	0.31	0.22	35.91	3.67	19.57	4.67
08158920	2002-04	0.436	0.138	0.466	---	0.45	0.25	0.18	14.00	7.33	7.81	7.00
08158930	2002-04	0.293	0.068	0.655	---	0.14	0.03	0.01	10.41	23.00	3.25	27.67
08159000	2002-04	0.324	0.144	0.094	0.0067	0.45	0.24	0.17	5.72	6.00	10.88	8.33
FBU	2002-04	0.107	0.308	0.148	---	0.75	0.59	0.49	2.66	20.33	5.83	15.67
FTB	2002-04	0.187	0.104	0.258	---	0.21	0.11	0.08	5.26	11.67	2.66	22.33

Appendix A – WQ, AQL, IC and flow statistics (cont.)

Station	Period	T_{3XQ50}	T_{qmean}	T_{dry}	T_{Q0.5-yr}	BF₁	BF₂	BF₃	F_{Ld}	F_{Ln}	F_{Hd}	F_{Hn}
08154700	2005-07	0.310	0.264	0.056	0.0002	0.62	0.45	0.37	8.71	2.33	7.71	11.67
08155200	2005-07	0.381	0.247	0.000	0.0062	0.68	0.51	0.42	0.00	0.00	24.64	3.67
08155240	2005-07	0.354	0.281	0.028	0.0011	0.70	0.54	0.46	10.33	1.00	26.90	3.33
08155300	2005-07	0.376	0.235	0.640	---	0.62	0.44	0.34	53.92	4.33	27.20	3.33
08155400	2005-07	0.333	0.235	0.363	0.0003	0.63	0.45	0.36	44.22	3.00	39.14	2.33
08156800	2005-07	0.456	0.109	0.643	0.0003	0.16	0.04	0.02	10.83	21.67	3.56	25.67
08157500	2005-07	0.166	0.138	0.000	0.0003	0.29	0.19	0.16	0.00	0.00	2.92	32.00
08157600	2005-07	0.495	0.184	0.622	0.0001	0.34	0.22	0.18	10.29	19.67	6.59	12.33
08157700	2005-07	0.347	0.168	0.460	0.0003	0.33	0.20	0.16	8.23	20.33	3.69	24.33
08158050	2005-07	---	---	---	---	---	---	---	---	---	---	---
08158600	2005-07	0.271	0.173	0.009	0.0015	0.39	0.24	0.20	10.00	0.33	4.71	19.33
08158700	2005-07	0.388	0.275	0.417	0.0019	0.72	0.55	0.47	114.25	1.33	45.50	2.00
08158810	2005-07	0.380	0.265	0.342	---	0.70	0.55	0.47	62.33	2.00	30.44	3.00
08158827	2005-07	---	---	---	---	---	---	---	---	---	---	---
08158840	2005-07	0.495	0.150	0.553	0.0008	0.56	0.36	0.27	60.50	3.33	22.08	4.00
08158920	2005-07	0.422	0.210	0.532	---	0.50	0.32	0.24	20.07	9.67	7.57	11.67
08158930	2005-07	0.496	0.086	0.646	---	0.16	0.04	0.02	12.16	19.33	4.29	21.00
08158970	2005-07	0.192	0.154	0.000	---	0.43	0.26	0.21	0.00	0.00	4.13	2.67
08159000	2005-07	0.350	0.200	0.199	---	0.49	0.30	0.22	14.53	5.00	8.84	10.33
FBU	2005-07	0.416	0.336	0.104	---	0.79	0.67	0.60	9.31	4.33	4.49	20.33
FTB	2005-07	0.284	0.178	0.146	---	0.40	0.27	0.21	5.88	8.67	3.65	27.00

Appendix A – WQ, AQL, IC and flow statistics (cont.)

Station	Period	Q _{mean} /area	Q _{peak} /area	Q ₅₀ /area	Q ₉₀ /area	Q _{mean±} /area	Q _{mean(ln)} /area	+mean/area	-mean/area
08157000	1958-68	0.127	13.24	0.05	0.141	0.13	0.08	0.24	0.17
08157500	1958-68	0.143	12.23	0.06	0.167	0.14	0.10	0.21	0.15
08158600	1958-68	0.062	6.43	0.01	0.112	0.07	0.05	0.10	0.04
08156700	1969-75	0.068	3.18	0.00	0.068	0.07	0.03	0.19	0.10
08157000	1969-75	0.116	10.84	0.03	0.148	0.12	0.06	0.21	0.14
08157500	1969-75	0.126	13.05	0.04	0.171	0.13	0.08	0.18	0.14
08158600	1969-75	0.071	7.52	0.02	0.115	0.07	0.06	0.14	0.05
08158970	1969-75	0.021	0.63	0.01	0.011	0.02	0.01	0.04	0.03
08154700	1976-85	0.070	8.11	0.02	0.125	0.07	0.07	0.12	0.04
08155200	1976-85	0.066	5.22	0.01	0.127	0.07	0.12	0.08	0.03
08155300	1976-85	0.052	8.61	0.00	0.126	0.14	0.26	0.19	0.05
08156700	1976-85	0.076	19.48	0.00	0.070	0.08	0.03	0.20	0.12
08156800	1976-85	0.075	9.64	0.00	0.038	0.19	0.17	0.38	0.16
08157000	1976-85	0.115	10.84	0.03	0.148	0.12	0.07	0.20	0.14
08157500	1976-85	0.112	10.04	0.03	0.160	0.11	0.06	0.17	0.13
08158050	1976-85	0.738	19.90	0.00	0.198	0.85	0.27	0.22	0.13
08158600	1976-85	0.078	12.38	0.02	0.103	0.08	0.07	0.17	0.06
08158700	1976-85	0.049	3.60	0.01	0.123	0.05	0.05	0.04	0.02
08158800	1976-85	0.029	5.07	0.00	0.003	0.07	0.03	0.13	0.04
08158810	1976-85	0.085	13.12	0.02	0.158	0.09	0.08	0.11	0.03
08158840	1976-85	0.091	16.05	0.01	0.175	0.11	0.15	0.21	0.07
08158920	1976-85	0.103	24.36	0.01	0.187	0.17	0.18	0.25	0.11
08158930	1976-85	0.131	4.07	0.05	0.184	0.13	0.09	0.35	0.17
08158970	1976-85	0.054	18.60	0.01	0.068	0.05	0.03	0.09	0.06
08159000	1976-85	0.041	6.99	0.00	0.071	0.04	0.03	0.07	0.03
08154700	1986-92	0.118	7.69	0.03	0.222	0.12	0.12	0.14	0.06
08155200	1986-92	0.106	8.64	0.01	0.242	0.11	0.49	0.13	0.04
08155240	1986-92	0.108	10.17	0.01	0.254	0.11	0.19	0.10	0.04
08155300	1986-92	0.093	14.47	0.00	0.163	0.21	1.12	0.28	0.08
08156800	1986-92	0.104	12.07	0.00	0.178	0.18	0.28	0.41	0.17
08157000	1986-92	0.186	3.47	0.04	0.263	0.19	0.11	0.30	0.28
08158050	1986-92	0.071	3.43	0.00	0.018	0.09	0.02	0.24	0.13
08158600	1986-92	0.120	13.08	0.03	0.199	0.12	0.09	0.23	0.10
08158700	1986-92	0.087	6.39	0.01	0.198	0.09	0.16	0.07	0.03
08158800	1986-92	0.137	3.04	0.00	0.379	0.22	3.86	0.25	0.06
08158810	1986-92	0.108	14.34	0.02	0.244	0.13	0.27	0.14	0.05
08158840	1986-92	0.114	13.36	0.01	0.214	0.17	0.20	0.29	0.10
08158920	1986-92	0.129	15.75	0.00	0.224	0.24	0.35	0.38	0.16
08158970	1986-92	0.068	2.15	0.03	0.068	0.07	0.08	0.10	0.06
08159000	1986-92	0.052	10.56	0.00	0.096	0.07	0.09	0.09	0.03
08154700	1993-96	0.079	5.50	0.03	0.152	0.08	0.09	0.11	0.04
08155200	1993-96	0.032	2.52	0.00	0.091	0.04	0.12	0.03	0.01
08155240	1993-96	0.036	2.77	0.00	0.090	0.04	0.05	0.02	0.01
08155300	1993-96	0.023	3.99	0.00	0.054	0.08	0.09	0.09	0.03
08155400	1993-96	---	---	---	---	---	---	---	---
08156800	1993-96	0.093	5.95	0.00	0.112	0.25	0.89	0.49	0.22
08157000	1993-96	0.135	4.68	0.04	0.121	0.14	0.08	0.21	0.15
08157500	1993-96	0.155	4.87	0.03	0.205	0.16	0.08	0.25	0.16
08157600	1993-96	---	---	---	---	---	---	---	---
08158050	1993-96	0.103	8.99	0.00	0.098	0.16	0.12	0.38	0.17
08158600	1993-96	0.071	7.37	0.02	0.106	0.07	0.06	0.16	0.06
08158700	1993-96	0.035	4.29	0.01	0.078	0.04	0.07	0.02	0.01
08158800	1993-96	0.009	2.15	0.00	0.000	0.03	0.01	0.07	0.02
08158810	1993-96	0.041	3.50	0.00	0.112	0.05	0.10	0.04	0.02
08158827	1993-96	---	---	---	---	---	---	---	---
08158840	1993-96	0.066	7.13	0.00	0.126	0.17	0.22	0.19	0.07
08158920	1993-96	0.074	0.40	0.06	0.140	0.08	0.11	0.05	0.02
08159000	1993-96	0.011	2.32	0.00	0.015	0.02	0.01	0.03	0.01
FBU	1993-96	0.065	2.08	0.01	0.202	0.09	0.62	0.02	0.02

Appendix A – WQ, AQL, IC and flow statistics (cont.)

Station	Period	Q _{mean} /area	Q _{peak} /area	Q ₅₀ /area	Q ₉₀ /area	Q _{mean±} /area	Q _{mean(ln)} /area	+ _{mean} /area	- _{mean} /area
08154700	1997-98	0.179	8.18	0.08	0.322	0.18	0.30	0.26	0.07
08155200	1997-98	0.139	5.75	0.03	0.317	0.15	0.72	0.15	0.05
08155240	1997-98	0.154	5.34	0.05	0.351	0.16	0.55	0.19	0.05
08155300	1997-98	0.122	5.06	0.01	0.287	0.23	0.37	0.30	0.07
08155400	1997-98	0.454	2.66	0.39	0.923	0.45	4.77	0.30	0.05
08156800	1997-98	0.120	13.12	0.00	0.178	0.22	0.31	0.46	0.21
08157500	1997-98	0.455	6.94	0.08	1.345	0.46	0.36	0.85	0.41
08157600	1997-98	0.201	14.14	0.03	0.302	0.21	0.15	0.47	0.23
08157700	1997-98	0.113	11.65	0.02	0.231	0.13	0.11	0.17	0.13
08158050	1997-98	0.143	14.26	0.01	0.252	0.18	0.12	0.35	0.19
08158600	1997-98	0.131	9.63	0.05	0.187	0.13	0.14	0.24	0.08
08158700	1997-98	0.155	5.18	0.06	0.350	0.15	0.21	0.14	0.04
08158810	1997-98	0.181	11.47	0.05	0.416	0.20	0.36	0.23	0.08
08158840	1997-98	0.157	10.15	0.03	0.410	0.24	0.26	0.33	0.10
08159000	1997-98	0.086	8.97	0.00	0.160	0.10	0.12	0.15	0.05
FBU	1997-98	0.292	4.80	0.17	0.719	0.29	0.56	0.10	0.06
08154700	1999-2001	0.100	5.99	0.02	0.236	0.11	0.23	0.10	0.04
08155200	1999-2001	0.055	5.47	0.01	0.169	0.08	0.23	0.07	0.02
08155240	1999-2001	0.055	4.26	0.01	0.173	0.06	0.21	0.05	0.02
08155300	1999-2001	0.036	3.75	0.00	0.126	0.11	0.47	0.09	0.03
08155400	1999-2001	0.039	3.85	0.00	0.130	0.06	0.10	0.07	0.02
08156800	1999-2001	0.101	13.24	0.00	0.121	0.27	1.08	0.54	0.27
08157500	1999-2001	0.144	15.39	0.03	0.193	0.14	0.08	0.23	0.15
08157600	1999-2001	0.237	12.43	0.04	0.431	0.26	0.23	0.38	0.24
08157700	1999-2001	0.326	23.04	0.03	0.888	0.44	0.80	0.36	0.20
08158050	1999-2001	0.111	14.38	0.01	0.117	0.17	0.13	0.35	0.17
08158600	1999-2001	0.105	7.04	0.03	0.196	0.11	0.12	0.15	0.07
08158700	1999-2001	0.045	4.48	0.01	0.129	0.05	0.11	0.05	0.01
08158810	1999-2001	0.066	2.44	0.01	0.186	0.08	0.15	0.08	0.02
08158827	1999-2001	---	---	---	---	---	---	---	---
08158840	1999-2001	0.076	2.69	0.00	0.267	0.13	0.18	0.12	0.04
08158930	1999-2001	0.063	10.29	0.00	0.036	0.09	0.03	0.24	0.10
08159000	1999-2001	0.033	9.79	0.00	0.045	0.04	0.03	0.09	0.03
FBU	1999-2001	0.128	1.72	0.02	0.342	0.17	0.29	0.04	0.02
08154700	2002-04	0.132	7.76	0.05	0.256	0.13	0.14	0.19	0.05
08155200	2002-04	0.109	11.26	0.02	0.209	0.11	0.13	0.14	0.04
08155240	2002-04	0.107	8.83	0.03	0.214	0.11	0.15	0.12	0.04
08155300	2002-04	0.084	8.37	0.00	0.178	0.16	0.35	0.21	0.05
08155400	2002-04	0.101	8.03	0.00	0.194	0.11	0.16	0.13	0.04
08156800	2002-04	0.108	10.48	0.00	0.082	0.16	0.08	0.49	0.20
08157500	2002-04	0.216	18.02	0.05	0.279	0.22	0.12	0.36	0.23
08157600	2002-04	0.116	7.73	0.01	0.131	0.19	0.18	0.26	0.23
08157700	2002-04	1.383	11.56	1.47	2.643	1.38	8.44	0.65	0.33
08158600	2002-04	0.129	7.79	0.04	0.223	0.13	0.10	0.28	0.09
08158700	2002-04	0.108	6.52	0.03	0.246	0.11	0.25	0.12	0.04
08158800	2002-04	---	---	---	---	---	---	---	---
08158810	2002-04	0.139	14.29	0.02	0.258	0.17	0.20	0.30	0.08
08158827	2002-04	---	---	---	---	---	---	---	---
08158840	2002-04	0.108	11.40	0.01	0.214	0.15	0.17	0.31	0.07
08158920	2002-04	0.070	7.15	0.00	0.092	0.12	0.11	0.19	0.08
08158930	2002-04	0.042	6.97	0.00	0.020	0.07	0.02	0.19	0.09
08159000	2002-04	0.059	5.79	0.00	0.100	0.06	0.11	0.10	0.03
FBU	2002-04	0.245	5.03	0.19	0.586	0.25	0.72	0.08	0.04
FTB	2002-04	0.148	7.99	0.02	0.154	0.16	0.12	0.24	0.21

Appendix A – WQ, AQL, IC and flow statistics (cont.)

Station	Period	Q _{mean} /area	Q _{peak} /area	Q ₅₀ /area	Q ₉₀ /area	Q _{mean±} /area	Q _{mean(ln)} /area	+ _{mean} /area	- _{mean} /area
08154700	2005-07	0.089	2.52	0.02	0.229	0.09	0.12	0.09	0.03
08155200	2005-07	0.062	1.48	0.00	0.202	0.06	0.08	0.04	0.02
08155240	2005-07	0.061	1.42	0.01	0.180	0.06	0.11	0.04	0.02
08155300	2005-07	0.045	1.67	0.00	0.137	0.12	0.43	0.11	0.03
08155400	2005-07	0.036	1.04	0.00	0.115	0.05	0.13	0.05	0.02
08156800	2005-07	0.085	7.13	0.00	0.120	0.19	0.31	0.39	0.19
08157500	2005-07	0.172	11.19	0.04	0.283	0.17	0.10	0.27	0.18
08157600	2005-07	0.112	4.11	0.00	0.204	0.22	0.25	0.28	0.19
08157700	2005-07	0.139	11.78	0.01	0.282	0.17	0.18	0.27	0.15
08158050	2005-07	---	---	---	---	---	---	---	---
08158600	2005-07	0.128	12.02	0.03	0.223	0.13	0.11	0.23	0.10
08158700	2005-07	0.055	1.86	0.00	0.168	0.09	0.58	0.06	0.02
08158810	2005-07	0.084	2.42	0.01	0.215	0.12	0.19	0.10	0.03
08158827	2005-07	---	---	---	---	---	---	---	---
08158840	2005-07	0.062	1.78	0.00	0.116	0.12	0.18	0.11	0.04
08158920	2005-07	0.059	2.14	0.00	0.155	0.11	0.17	0.13	0.05
08158930	2005-07	0.023	4.32	0.00	0.016	0.05	0.03	0.11	0.05
08158970	2005-07	0.015	0.51	0.00	0.022	0.02	0.01	0.02	0.01
08159000	2005-07	0.032	3.09	0.00	0.082	0.04	0.06	0.06	0.02
FBU	2005-07	0.232	2.48	0.06	0.672	0.25	0.50	0.06	0.03
FTB	2005-07	0.237	15.03	0.03	0.676	0.24	0.49	0.26	0.21

Appendix A – WQ, AQL, IC and flow statistics (cont.)

Station	Period	ln(A)	Ln(Q _{mean})	ln(Q _{peak})	ln(Q ₉₀)	ln(+ _{mean})	ln(- _{mean})	ln(F _{Ha})
08157000	1958-68	7.26	0.59	5.24	0.69	1.21	0.87	1.06
08157500	1958-68	7.90	1.35	5.80	1.50	1.71	1.41	1.07
08158600	1958-68	10.41	3.02	7.66	3.61	3.48	2.61	1.97
08156700	1969-75	8.32	1.04	4.88	1.03	2.03	1.43	0.96
08157000	1969-75	7.26	0.50	5.04	0.74	1.08	0.67	0.92
08157500	1969-75	7.90	1.22	5.86	1.53	1.59	1.35	0.87
08158600	1969-75	10.41	3.16	7.82	3.64	3.82	2.87	1.84
08158970	1969-75	9.77	1.28	4.71	0.69	2.01	1.61	0.63
08154700	1976-85	9.58	2.31	7.06	2.89	2.84	1.71	2.23
08155200	1976-85	10.96	3.63	8.01	4.29	3.88	2.75	2.52
08155300	1976-85	11.22	3.65	8.77	4.54	4.94	3.61	2.82
08156700	1976-85	8.32	1.14	6.69	1.06	2.11	1.63	1.14
08156800	1976-85	8.97	1.77	6.63	1.10	3.39	2.52	1.72
08157000	1976-85	7.26	0.49	5.04	0.74	1.03	0.71	0.98
08157500	1976-85	7.90	1.10	5.60	1.46	1.54	1.23	0.94
08158050	1976-85	9.03	4.12	7.41	2.80	2.93	2.40	1.32
08158600	1976-85	10.41	3.25	8.32	3.53	4.04	3.06	1.53
08158700	1976-85	11.28	3.66	7.96	4.57	3.51	2.66	2.92
08158800	1976-85	11.58	3.42	8.59	1.28	4.90	3.77	2.67
08158810	1976-85	8.85	1.77	6.82	2.40	2.02	0.86	2.67
08158840	1976-85	8.63	1.63	6.80	2.28	2.48	1.31	2.54
08158920	1976-85	8.30	1.42	6.88	2.01	2.29	1.46	1.86
08158930	1976-85	9.39	2.75	6.19	3.09	3.72	3.02	0.83
08158970	1976-85	9.77	2.25	8.09	2.48	2.73	2.41	1.66
08159000	1976-85	12.24	4.44	9.58	5.00	4.99	3.95	2.21
08154700	1986-92	9.58	2.83	7.01	3.47	3.01	2.13	2.29
08155200	1986-92	10.96	4.11	8.51	4.93	4.33	3.17	2.85
08155240	1986-92	11.14	4.31	8.85	5.16	4.26	3.28	3.01
08155300	1986-92	11.22	4.24	9.29	4.80	5.34	4.12	2.98
08156800	1986-92	8.97	2.10	6.85	2.64	3.47	2.61	1.20
08157000	1986-92	7.26	0.97	3.90	1.32	1.46	1.37	0.69
08158050	1986-92	9.03	1.78	5.66	0.41	3.01	2.35	1.02
08158600	1986-92	10.41	3.68	8.37	4.19	4.33	3.46	1.47
08158700	1986-92	11.28	4.23	8.53	5.06	3.99	3.07	2.93
08158800	1986-92	11.58	4.98	8.08	6.00	5.58	4.18	2.43
08158810	1986-92	8.85	2.02	6.91	2.83	2.29	1.21	3.28
08158840	1986-92	8.63	1.85	6.62	2.48	2.77	1.70	3.16
08158920	1986-92	8.30	1.64	6.45	2.20	2.73	1.84	1.95
08158970	1986-92	9.77	2.47	5.93	2.48	2.89	2.32	1.23
08159000	1986-92	12.24	4.67	9.99	5.29	5.23	4.19	2.23
08154700	1993-96	9.58	2.43	6.68	3.09	2.79	1.65	1.98
08155200	1993-96	10.96	2.92	7.28	3.95	2.67	1.76	3.03
08155240	1993-96	11.14	3.21	7.55	4.13	2.71	1.83	3.41
08155300	1993-96	11.22	2.86	8.00	3.69	4.17	3.07	3.41
08155400	1993-96	---	---	---	---	---	---	---
08156800	1993-96	8.97	1.98	6.15	2.17	3.65	2.86	1.38
08157000	1993-96	7.26	0.65	4.20	0.54	1.07	0.74	0.83
08157500	1993-96	7.90	1.43	4.87	1.71	1.90	1.44	0.82
08157600	1993-96	---	---	---	---	---	---	---
08158050	1993-96	9.03	2.15	6.62	2.10	3.45	2.63	1.24
08158600	1993-96	10.41	3.16	7.80	3.56	3.94	2.97	1.37
08158700	1993-96	11.28	3.31	8.13	4.13	2.96	2.26	3.33
08158800	1993-96	11.58	2.28	7.74	-0.67	4.30	2.95	2.86
08158810	1993-96	8.85	1.04	5.50	2.05	1.12	0.16	3.34
08158827	1993-96	---	---	---	---	---	---	---
08158840	1993-96	8.63	1.31	5.99	1.96	2.38	1.34	3.25
08158920	1993-96	8.30	1.09	2.77	1.72	0.68	-0.24	1.73
08159000	1993-96	12.24	3.15	8.48	3.43	4.05	3.10	1.92
FBU	1993-96	8.17	0.83	4.30	1.96	-0.44	-0.59	3.02

Appendix A – WQ, AQL, IC and flow statistics (cont.)

Station	Period	ln(A)	Ln(Q _{mean})	ln(Q _{peak})	ln(Q ₉₀)	ln(+ _{mean})	ln(- _{mean})	ln(F _{Ha})
08154700	1997-98	9.58	3.25	7.07	3.84	3.62	2.28	2.00
08155200	1997-98	10.96	4.38	8.10	5.20	4.46	3.31	2.37
08155240	1997-98	11.14	4.66	8.21	5.49	4.88	3.44	2.72
08155300	1997-98	11.22	4.51	8.24	5.37	5.41	3.98	2.72
08155400	1997-98	11.25	5.85	7.62	6.56	5.42	3.71	2.12
08156800	1997-98	8.97	2.25	6.94	2.64	3.58	2.79	1.20
08157500	1997-98	7.90	2.51	5.23	3.59	3.13	2.40	0.42
08157600	1997-98	6.66	0.45	4.70	0.85	1.30	0.59	1.21
08157700	1997-98	6.71	-0.07	4.56	0.64	0.34	0.05	1.25
08158050	1997-98	9.03	2.48	7.08	3.04	3.38	2.77	1.22
08158600	1997-98	10.41	3.77	8.07	4.13	4.39	3.31	1.48
08158700	1997-98	11.28	4.81	8.32	5.62	4.69	3.56	2.32
08158810	1997-98	8.85	2.53	6.68	3.37	2.79	1.66	2.54
08158840	1997-98	8.63	2.18	6.35	3.14	2.92	1.71	2.90
08159000	1997-98	12.24	5.18	9.83	5.81	5.73	4.59	2.16
FBU	1997-98	8.17	2.33	5.13	3.23	1.23	0.72	1.34
08154700	1999-2001	9.58	2.67	6.76	3.53	2.69	1.83	2.32
08155200	1999-2001	10.96	3.44	8.05	4.57	3.66	2.37	3.22
08155240	1999-2001	11.14	3.64	7.98	4.78	3.50	2.35	3.03
08155300	1999-2001	11.22	3.30	7.94	4.54	4.20	3.08	3.12
08155400	1999-2001	11.25	3.41	7.99	4.61	3.92	2.82	2.84
08156800	1999-2001	8.97	2.07	6.95	2.25	3.75	3.05	1.36
08157500	1999-2001	7.90	1.35	6.03	1.65	1.83	1.40	1.03
08157600	1999-2001	6.66	0.61	4.57	1.21	1.09	0.63	1.23
08157700	1999-2001	6.71	0.99	5.25	1.99	1.08	0.50	1.65
08158050	1999-2001	9.03	2.22	7.09	2.28	3.37	2.65	1.31
08158600	1999-2001	10.41	3.55	7.75	4.17	3.89	3.16	1.50
08158700	1999-2001	11.28	3.57	8.17	4.62	3.67	2.47	3.42
08158810	1999-2001	8.85	1.53	5.14	2.56	1.73	0.49	3.11
08158827	1999-2001	---	---	---	---	---	---	---
08158840	1999-2001	8.63	1.46	5.02	2.71	1.94	0.79	4.00
08158930	1999-2001	9.39	2.01	7.11	1.46	3.36	2.47	1.34
08159000	1999-2001	12.24	4.21	9.92	4.54	5.18	4.20	1.83
FBU	1999-2001	8.17	1.51	4.11	2.49	0.23	-0.21	2.06
08154700	2002-04	9.58	2.94	7.02	3.61	3.30	2.02	1.93
08155200	2002-04	10.96	4.14	8.77	4.79	4.41	3.22	2.78
08155240	2002-04	11.14	4.30	8.71	4.99	4.39	3.21	2.61
08155300	2002-04	11.22	4.14	8.74	4.89	5.05	3.65	2.78
08155400	2002-04	11.25	4.35	8.73	5.00	4.56	3.37	2.84
08156800	2002-04	8.97	2.14	6.71	1.86	3.66	2.77	1.38
08157500	2002-04	7.90	1.76	6.18	2.02	2.28	1.83	0.99
08157600	2002-04	6.66	-0.11	4.10	0.02	0.71	0.59	1.24
08157700	2002-04	6.71	2.43	4.56	3.08	1.68	1.00	1.94
08158600	2002-04	10.41	3.75	7.86	4.30	4.52	3.42	1.38
08158700	2002-04	11.28	4.45	8.55	5.27	4.55	3.34	2.83
08158800	2002-04	---	---	---	---	---	---	---
08158810	2002-04	8.85	2.27	6.90	2.89	3.03	1.75	3.42
08158827	2002-04	---	---	---	---	---	---	---
08158840	2002-04	8.63	1.81	6.46	2.48	2.86	1.42	2.97
08158920	2002-04	8.30	1.04	5.66	1.31	2.03	1.12	2.06
08158930	2002-04	9.39	1.60	6.73	0.88	3.11	2.37	1.18
08159000	2002-04	12.24	4.80	9.39	5.34	5.37	4.16	2.39
FBU	2002-04	8.17	2.16	5.18	3.03	1.03	0.39	1.76
FTB	2002-04	7.42	0.91	4.89	0.94	1.37	1.25	0.98

Appendix A – WQ, AQL, IC and flow statistics (cont.)

Station	Period	ln(A)	Ln(Q _{mean})	ln(Q _{peak})	ln(Q ₉₀)	ln(+ _{mean})	ln(- _{mean})	ln(F _{Ha})
08154700	2005-07	9.58	2.56	5.90	3.50	2.53	1.56	2.04
08155200	2005-07	10.96	3.57	6.74	4.75	3.14	2.39	3.20
08155240	2005-07	11.14	3.73	6.89	4.82	3.27	2.36	3.29
08155300	2005-07	11.22	3.51	7.13	4.62	4.39	3.22	3.30
08155400	2005-07	11.25	3.32	6.68	4.48	3.55	2.57	3.67
08156800	2005-07	8.97	1.90	6.33	2.24	3.42	2.71	1.27
08157500	2005-07	7.90	1.53	5.71	2.03	2.00	1.56	1.04
08157600	2005-07	6.66	-0.14	3.46	0.46	0.79	0.39	1.88
08157700	2005-07	6.71	0.13	4.58	0.85	0.81	0.18	1.32
08158050	2005-07	---	---	---	---	---	---	---
08158600	2005-07	10.41	3.75	8.29	4.30	4.34	3.48	1.55
08158700	2005-07	11.28	3.77	7.29	4.89	3.87	2.84	3.82
08158810	2005-07	8.85	1.77	5.13	2.71	1.92	0.84	3.42
08158827	2005-07	---	---	---	---	---	---	---
08158840	2005-07	8.63	1.25	4.61	1.87	1.82	0.73	3.09
08158920	2005-07	8.30	0.86	4.45	1.82	1.63	0.67	2.02
08158930	2005-07	9.39	1.02	6.25	0.64	2.54	1.71	1.46
08158970	2005-07	9.77	0.99	4.50	1.35	1.27	0.78	1.42
08159000	2005-07	12.24	4.19	8.77	5.14	4.83	3.76	2.18
FBU	2005-07	8.17	2.10	4.47	3.17	0.77	0.19	1.50
FTB	2005-07	7.42	1.38	5.53	2.42	1.47	1.26	1.18

Appendix A – WQ, AQL, IC and flow statistics (cont.)

Station	Period	ln(Q _{mean} /area)	ln(Q _{peak} /area)	ln(+ _{mean} /area)	ln(- _{mean} /area)
08157000	1958-68	-2.06	2.58	-1.44	-1.79
08157500	1958-68	-1.94	2.50	-1.58	-1.89
08158600	1958-68	-2.78	1.86	-2.32	-3.19
08156700	1969-75	-2.68	1.16	-1.68	-2.29
08157000	1969-75	-2.15	2.38	-1.58	-1.98
08157500	1969-75	-2.07	2.57	-1.70	-1.95
08158600	1969-75	-2.65	2.02	-1.98	-2.93
08158970	1969-75	-3.89	-0.46	-3.15	-3.56
08154700	1976-85	-2.66	2.09	-2.14	-3.26
08155200	1976-85	-2.72	1.65	-2.47	-3.61
08155300	1976-85	-2.96	2.15	-1.67	-3.01
08156700	1976-85	-2.58	2.97	-1.61	-2.09
08156800	1976-85	-2.59	2.27	-0.98	-1.85
08157000	1976-85	-2.16	2.38	-1.62	-1.95
08157500	1976-85	-2.19	2.31	-1.75	-2.07
08158050	1976-85	-0.30	2.99	-1.49	-2.02
08158600	1976-85	-2.56	2.52	-1.77	-2.74
08158700	1976-85	-3.02	1.28	-3.16	-4.02
08158800	1976-85	-3.55	1.62	-2.07	-3.20
08158810	1976-85	-2.47	2.57	-2.23	-3.38
08158840	1976-85	-2.40	2.78	-1.55	-2.72
08158920	1976-85	-2.27	3.19	-1.40	-2.24
08158930	1976-85	-2.03	1.40	-1.06	-1.76
08158970	1976-85	-2.91	2.92	-2.43	-2.76
08159000	1976-85	-3.20	1.95	-2.65	-3.69
08154700	1986-92	-2.14	2.04	-1.96	-2.85
08155200	1986-92	-2.25	2.16	-2.02	-3.18
08155240	1986-92	-2.22	2.32	-2.27	-3.26
08155300	1986-92	-2.38	2.67	-1.27	-2.49
08156800	1986-92	-2.27	2.49	-0.89	-1.75
08157000	1986-92	-1.68	1.25	-1.19	-1.28
08158050	1986-92	-2.65	1.23	-1.41	-2.08
08158600	1986-92	-2.12	2.57	-1.47	-2.34
08158700	1986-92	-2.44	1.85	-2.68	-3.61
08158800	1986-92	-1.99	1.11	-1.39	-2.79
08158810	1986-92	-2.23	2.66	-1.96	-3.04
08158840	1986-92	-2.17	2.59	-1.25	-2.33
08158920	1986-92	-2.05	2.76	-0.96	-1.85
08158970	1986-92	-2.69	0.77	-2.27	-2.85
08159000	1986-92	-2.96	2.36	-2.41	-3.45
08154700	1993-96	-2.54	1.70	-2.18	-3.32
08155200	1993-96	-3.43	0.93	-3.68	-4.60
08155240	1993-96	-3.32	1.02	-3.83	-4.71
08155300	1993-96	-3.76	1.38	-2.45	-3.54
08155400	1993-96	---	---	---	---
08156800	1993-96	-2.38	1.78	-0.72	-1.50
08157000	1993-96	-2.00	1.54	-1.58	-1.92
08157500	1993-96	-1.86	1.58	-1.39	-1.85
08157600	1993-96	---	---	---	---
08158050	1993-96	-2.27	2.20	-0.97	-1.79
08158600	1993-96	-2.64	2.00	-1.86	-2.83
08158700	1993-96	-3.36	1.46	-3.72	-4.41
08158800	1993-96	-4.69	0.77	-2.67	-4.02
08158810	1993-96	-3.20	1.25	-3.13	-4.08
08158827	1993-96	---	---	---	---
08158840	1993-96	-2.72	1.96	-1.64	-2.69
08158920	1993-96	-2.60	-0.92	-3.01	-3.93
08159000	1993-96	-4.49	0.84	-3.58	-4.54
FBU	1993-96	-2.73	-1.28	-4.00	-4.15

Appendix A – WQ, AQL, IC and flow statistics (cont.)

Station	Period	ln(Q _{mean} /area)	ln(Q _{peak} /area)	ln(+ _{mean} /area)	ln(- _{mean} /area)
08154700	1997-98	-1.72	2.10	-1.36	-2.69
08155200	1997-98	-1.97	1.75	-1.90	-3.04
08155240	1997-98	-1.87	1.68	-1.66	-3.09
08155300	1997-98	-2.11	1.62	-1.20	-2.63
08155400	1997-98	-0.79	0.98	-1.22	-2.93
08156800	1997-98	-2.12	2.57	-0.78	-1.58
08157500	1997-98	-0.79	1.94	-0.16	-0.89
08157600	1997-98	-1.61	2.65	-0.75	-1.46
08157700	1997-98	-2.18	2.46	-1.77	-2.06
08158050	1997-98	-1.95	2.66	-1.05	-1.66
08158600	1997-98	-2.03	2.27	-1.41	-2.49
08158700	1997-98	-1.87	1.64	-1.98	-3.11
08158810	1997-98	-1.71	2.44	-1.46	-2.58
08158840	1997-98	-1.85	2.32	-1.11	-2.32
08159000	1997-98	-2.45	2.19	-1.91	-3.04
FBU	1997-98	-1.23	-1.26	-2.34	-2.85
08154700	1999-2001	-2.30	1.79	-2.28	-3.14
08155200	1999-2001	-2.91	1.70	-2.69	-3.98
08155240	1999-2001	-2.90	1.45	-3.03	-4.19
08155300	1999-2001	-3.32	1.32	-2.41	-3.53
08155400	1999-2001	-3.24	1.35	-2.72	-3.82
08156800	1999-2001	-2.30	2.58	-0.61	-1.32
08157500	1999-2001	-1.94	2.73	-1.46	-1.89
08157600	1999-2001	-1.44	2.52	-0.96	-1.42
08157700	1999-2001	-1.12	3.14	-1.03	-1.61
08158050	1999-2001	-2.20	2.67	-1.05	-1.77
08158600	1999-2001	-2.25	1.95	-1.91	-2.64
08158700	1999-2001	-3.11	1.50	-3.00	-4.21
08158810	1999-2001	-2.71	0.89	-2.51	-3.76
08158827	1999-2001	---	---	---	---
08158840	1999-2001	-2.57	0.99	-2.09	-3.23
08158930	1999-2001	-2.77	2.33	-1.42	-2.31
08159000	1999-2001	-3.43	2.28	-2.45	-3.43
FBU	1999-2001	-2.05	-1.26	-3.33	-3.77
08154700	2002-04	-2.03	2.05	-1.68	-2.95
08155200	2002-04	-2.21	2.42	-1.94	-3.13
08155240	2002-04	-2.23	2.18	-2.14	-3.32
08155300	2002-04	-2.48	2.12	-1.56	-2.96
08155400	2002-04	-2.29	2.08	-2.08	-3.28
08156800	2002-04	-2.23	2.35	-0.71	-1.60
08157500	2002-04	-1.53	2.89	-1.01	-1.46
08157600	2002-04	-2.16	2.05	-1.34	-1.46
08157700	2002-04	0.32	2.45	-0.43	-1.11
08158600	2002-04	-2.05	2.05	-1.28	-2.39
08158700	2002-04	-2.23	1.87	-2.12	-3.33
08158800	2002-04	---	---	---	---
08158810	2002-04	-1.98	2.66	-1.21	-2.50
08158827	2002-04	---	---	---	---
08158840	2002-04	-2.22	2.43	-1.17	-2.61
08158920	2002-04	-2.65	1.97	-1.66	-2.57
08158930	2002-04	-3.18	1.94	-1.67	-2.41
08159000	2002-04	-2.84	1.76	-2.26	-3.47
FBU	2002-04	-1.41	-1.26	-2.53	-3.17
FTB	2002-04	-1.91	-0.54	-1.44	-1.57

Appendix A – WQ, AQL, IC and flow statistics (cont.)

Station	Period	$\ln(Q_{\text{mean}}/\text{area})$	$\ln(Q_{\text{peak}}/\text{area})$	$\ln(+_{\text{mean}}/\text{area})$	$\ln(-_{\text{mean}}/\text{area})$
08154700	2005-07	-2.42	0.93	-2.45	-3.41
08155200	2005-07	-2.78	0.39	-3.22	-3.97
08155240	2005-07	-2.80	0.35	-3.26	-4.18
08155300	2005-07	-3.10	0.52	-2.23	-3.39
08155400	2005-07	-3.32	0.04	-3.09	-4.07
08156800	2005-07	-2.46	1.96	-0.94	-1.66
08157500	2005-07	-1.76	-1.01	-1.29	-1.73
08157600	2005-07	-2.19	0.25	-1.26	-1.66
08157700	2005-07	-1.97	0.18	-1.30	-1.93
08158050	2005-07	---	---	---	---
08158600	2005-07	-2.06	2.49	-1.46	-2.32
08158700	2005-07	-2.90	0.62	-2.80	-3.84
08158810	2005-07	-2.48	0.88	-2.33	-3.41
08158827	2005-07	---	---	---	---
08158840	2005-07	-2.78	0.58	-2.20	-3.30
08158920	2005-07	-2.83	0.76	-2.06	-3.03
08158930	2005-07	-3.76	1.46	-2.24	-3.08
08158970	2005-07	-4.18	-0.67	-3.90	-4.39
08159000	2005-07	-3.45	1.13	-2.81	-3.88
FBU	2005-07	-1.46	-1.26	-2.79	-3.38
FTB	2005-07	-1.44	-0.51	-1.35	-1.55

Appendix B – Correlation Matrix

	A	IC	WQ	AQL	Q _{peak}	Q _{mean}	SD	COV	Q ₅₀	Q ₁₀	Q ₉₀
A	---	-0.435	0.742	0.436	0.844	0.760	0.834	0.252	0.302	0.050	0.736
IC	-0.435	---	-0.911	-0.397	-0.376	-0.380	-0.350	0.138	-0.192	0.089	-0.447
WQ	0.742	-0.911	---	0.425	0.560	0.645	0.609	-0.580	0.431	-0.070	0.689
AQL	0.436	-0.397	0.425	---	0.300	0.517	0.351	-0.246	0.536	0.372	0.570
Q _{peak}	0.844	-0.376	0.560	0.300	---	0.788	0.944	0.348	0.297	0.094	0.690
Q _{mean}	0.760	-0.380	0.645	0.517	0.788	---	0.912	-0.005	0.651	0.246	0.959
SD	0.834	-0.350	0.609	0.351	0.944	0.912	---	0.255	0.415	0.127	0.806
COV	0.252	0.138	-0.580	-0.246	0.348	-0.005	0.255	---	-0.248	-0.145	-0.133
Q ₅₀	0.302	-0.192	0.431	0.536	0.297	0.651	0.415	-0.248	---	0.602	0.659
Q ₁₀	0.050	0.089	-0.070	0.372	0.094	0.246	0.127	-0.145	0.602	---	0.214
Q ₉₀	0.736	-0.447	0.689	0.570	0.690	0.959	0.806	-0.133	0.659	0.214	---
Q _{mean+}	0.750	-0.396	0.588	0.464	0.774	0.929	0.871	0.057	0.465	0.102	0.905
Q _{geommean}	0.488	-0.332	0.410	0.644	0.448	0.664	0.530	-0.081	0.449	0.238	0.711
Q _{mean(ln)}	0.444	-0.346	0.595	0.350	0.442	0.612	0.499	-0.093	0.290	-0.084	0.663
SD _(ln)	0.206	-0.149	0.187	-0.219	0.152	0.268	0.207	-0.044	0.015	-0.404	0.290
COV _(ln)	0.093	-0.075	-0.037	-0.373	0.086	0.176	0.130	-0.028	-0.015	-0.278	0.180
+ _{mean}	0.782	-0.267	0.410	0.347	0.850	0.878	0.912	0.231	0.394	0.125	0.815
- _{mean}	0.809	-0.181	0.311	0.301	0.896	0.869	0.937	0.287	0.381	0.174	0.787
T _{3xQ50}	0.201	-0.287	0.459	-0.307	0.141	0.130	0.145	0.140	-0.234	-0.441	0.174
T _{OMean}	0.037	-0.438	0.884	0.450	-0.064	0.146	-0.032	-0.694	0.350	0.023	0.278
T _{dry}	-0.117	0.074	-0.175	-0.711	-0.148	-0.276	-0.181	0.334	-0.488	-0.577	-0.266
T _{Q0.5-yr}	0.308	-0.447	0.649	0.339	0.319	0.577	0.408	0.004	0.519	-0.074	0.587
BF ₁	0.185	-0.825	0.863	0.629	0.066	0.230	0.075	-0.592	0.303	0.043	0.371
BF ₂	0.095	-0.738	0.800	0.579	-0.013	0.154	-0.007	-0.661	0.277	0.055	0.296
BF ₃	0.054	-0.673	0.759	0.556	-0.050	0.113	-0.046	-0.682	0.268	0.075	0.252
F _{Ld}	0.185	-0.532	0.387	0.059	0.028	-0.005	0.003	0.064	-0.218	-0.349	0.088
F _{Ln}	-0.267	0.570	-0.394	-0.816	-0.207	-0.297	-0.214	0.224	-0.339	-0.401	-0.344
F _{Hd}	0.165	-0.666	0.692	0.339	-0.009	0.095	0.003	-0.307	-0.032	-0.227	0.229
F _{Hn}	-0.367	0.906	-0.904	-0.573	-0.227	-0.336	-0.247	0.146	-0.167	0.158	-0.435
Q _{mean/area}	-0.259	0.277	-0.245	-0.139	-0.170	-0.060	-0.103	-0.302	0.123	-0.017	-0.133
Q _{peak/area}	-0.299	0.279	-0.586	-0.274	0.000	-0.139	-0.033	0.360	-0.132	0.018	-0.261
Q _{50/area}	-0.118	0.207	0.018	0.287	-0.096	-0.061	-0.093	-0.267	0.175	0.013	-0.062
Q _{90/area}	-0.218	0.143	0.378	0.141	-0.168	-0.070	-0.143	-0.442	0.184	-0.030	-0.052
Q _{mean-/area}	-0.297	0.303	-0.383	-0.666	-0.194	-0.097	-0.127	-0.250	0.025	-0.117	-0.174
Q _{mean(ln)/area}	-0.104	0.177	0.016	-0.423	-0.075	-0.031	-0.069	-0.258	0.120	-0.104	-0.024
+ _{mean/area}	-0.436	0.675	-0.630	-0.671	-0.245	-0.264	-0.231	0.107	-0.135	-0.079	-0.333
- _{mean/area}	-0.488	0.841	-0.778	-0.724	-0.327	-0.389	-0.333	0.056	-0.236	-0.095	-0.454
ln(A)	0.817	-0.566	0.770	0.703	0.666	0.736	0.692	0.178	0.406	0.214	0.757
ln(Q _{mean})	0.713	-0.435	0.731	0.735	0.664	0.851	0.745	-0.028	0.587	0.320	0.843
ln(Q _{peak})	0.741	-0.469	0.621	0.564	0.745	0.753	0.757	0.368	0.420	0.267	0.713
ln(Q ₉₀)	0.646	-0.571	0.799	0.773	0.587	0.790	0.653	-0.251	0.564	0.279	0.842
ln(+ _{mean})	0.696	-0.275	0.450	0.504	0.671	0.752	0.718	0.303	0.436	0.255	0.725
ln(- _{mean})	0.700	-0.108	0.284	0.437	0.690	0.751	0.733	0.337	0.421	0.288	0.709
ln(F _{Hd})	0.323	-0.859	0.827	0.424	0.157	0.274	0.175	-0.195	0.095	-0.186	0.397
ln(Q _{mean/area})	-0.524	0.403	-0.253	-0.160	-0.273	-0.084	-0.181	-0.455	0.172	0.112	-0.146
ln(Q _{peak/area})	-0.025	0.288	-0.539	0.011	0.189	0.110	0.174	0.453	0.052	0.127	0.014
ln(+ _{mean/area})	-0.450	0.606	-0.558	-0.545	-0.184	-0.187	-0.155	0.168	-0.066	0.010	-0.277
ln(- _{mean/area})	-0.550	0.780	-0.737	-0.624	-0.291	-0.338	-0.282	0.123	-0.178	-0.005	-0.431

Appendix B – Correlation Matrix (cont.)

	Q _{mean+}	Q _{geomean}	Q _{mean(ln)}	SD _(ln)	COV _(ln)	+ _{mean}	- _{mean}	T _{3XQ50}	T _{QMean}	T _{dry}	T _{Q0.5-yr}
A	0.750	0.488	0.444	0.206	0.093	0.782	0.809	0.201	0.037	-0.117	0.308
IC	-0.396	-0.332	-0.346	-0.149	-0.075	-0.267	-0.181	-0.287	-0.438	0.074	-0.447
WQ	0.588	0.410	0.595	0.187	-0.037	0.410	0.311	0.459	0.884	-0.175	0.649
AQL	0.464	0.644	0.350	-0.219	-0.373	0.347	0.301	-0.307	0.450	-0.711	0.339
Q _{peak}	0.774	0.448	0.442	0.152	0.086	0.850	0.896	0.141	-0.064	-0.148	0.319
Q _{mean}	0.929	0.664	0.612	0.268	0.176	0.878	0.869	0.130	0.146	-0.276	0.577
SD	0.871	0.530	0.499	0.207	0.130	0.912	0.937	0.145	-0.032	-0.181	0.408
COV	0.057	-0.081	-0.093	-0.044	-0.028	0.231	0.287	0.140	-0.694	0.334	0.004
Q ₅₀	0.465	0.449	0.290	0.015	-0.015	0.394	0.381	-0.234	0.350	-0.488	0.519
Q ₁₀	0.102	0.238	-0.084	-0.404	-0.278	0.125	0.174	-0.441	0.023	-0.577	-0.074
Q ₉₀	0.905	0.711	0.663	0.290	0.180	0.815	0.787	0.174	0.278	-0.266	0.587
Q _{mean+}	---	0.814	0.765	0.307	0.219	0.943	0.906	0.237	0.110	-0.038	0.531
Q _{geomean}	0.814	---	0.611	0.020	-0.023	0.740	0.660	0.141	0.217	0.008	0.440
Q _{mean(ln)}	0.765	0.611	---	0.501	0.455	0.653	0.594	0.259	0.212	0.121	0.549
SD _(ln)	0.307	0.020	0.501	---	0.909	0.216	0.217	0.468	0.183	0.397	0.242
COV _(ln)	0.219	-0.023	0.455	0.909	---	0.156	0.172	0.295	0.062	0.329	0.107
+ _{mean}	0.943	0.740	0.653	0.216	0.156	---	0.979	0.204	-0.032	-0.022	0.414
- _{mean}	0.906	0.660	0.594	0.217	0.172	0.979	---	0.175	-0.093	-0.053	0.341
T _{3XQ50}	0.237	0.141	0.259	0.468	0.295	0.204	0.175	---	0.006	0.615	0.134
T _{QMean}	0.110	0.217	0.212	0.183	0.062	-0.032	-0.093	0.006	---	-0.234	0.261
T _{dry}	-0.038	0.008	0.121	0.397	0.329	-0.022	-0.053	0.615	-0.234	---	-0.266
T _{Q0.5-yr}	0.531	0.440	0.549	0.242	0.107	0.414	0.341	0.134	0.261	-0.266	---
BF ₁	0.206	0.272	0.274	0.125	0.004	0.059	-0.018	0.080	0.858	-0.278	0.302
BF ₂	0.116	0.195	0.218	0.105	0.004	-0.042	-0.110	0.000	0.874	-0.326	0.210
BF ₃	0.066	0.154	0.178	0.080	-0.002	-0.089	-0.151	-0.057	0.869	-0.363	0.155
F _{Ld}	0.134	0.140	0.248	0.263	0.159	0.080	0.025	0.363	0.131	0.411	-0.067
F _{Ln}	-0.216	-0.252	-0.117	0.345	0.313	-0.163	-0.135	0.339	-0.283	0.669	-0.236
F _{Hd}	0.162	0.183	0.293	0.276	0.134	0.014	-0.048	0.356	0.498	0.140	0.139
F _{Hn}	-0.376	-0.337	-0.380	-0.323	-0.150	-0.255	-0.181	-0.424	-0.509	-0.114	-0.378
Q _{mean} /area	-0.099	-0.113	-0.077	0.095	0.088	-0.166	-0.169	-0.364	0.362	-0.088	0.156
Q _{peak} /area	-0.151	-0.217	-0.157	-0.141	-0.045	-0.084	-0.046	-0.239	-0.383	-0.050	0.048
Q ₅₀ /area	-0.086	-0.048	-0.028	0.066	0.042	-0.103	-0.110	-0.384	0.515	-0.087	0.104
Q ₉₀ /area	-0.103	-0.046	-0.017	0.085	0.041	-0.150	-0.175	-0.297	0.614	-0.112	0.357
Q _{mean+} /area	-0.081	-0.085	-0.031	0.183	0.185	-0.148	-0.157	-0.210	0.290	0.114	-0.052
Q _{mean(ln)} /area	-0.005	0.001	0.137	0.279	0.260	-0.039	-0.052	-0.206	0.518	0.090	0.177
+ _{mean} /area	-0.212	-0.154	-0.128	0.054	0.165	-0.114	-0.102	-0.126	-0.272	0.288	-0.160
- _{mean} /area	-0.371	-0.330	-0.266	-0.050	0.093	-0.292	-0.253	-0.251	-0.337	0.191	-0.285
Ln(A)	0.746	0.594	0.530	0.296	0.180	0.713	0.723	0.252	0.124	-0.139	0.386
Ln(Q _{mean})	0.820	0.651	0.588	0.317	0.217	0.750	0.755	0.091	0.260	-0.313	0.512
Ln(Q _{peak})	0.751	0.557	0.499	0.237	0.165	0.760	0.786	0.118	-0.058	-0.196	0.444
Ln(Q ₉₀)	0.763	0.655	0.595	0.298	0.188	0.662	0.655	0.133	0.465	-0.338	0.497
Ln(+ _{mean})	0.790	0.650	0.567	0.274	0.211	0.810	0.821	0.182	-0.084	-0.041	0.452
Ln(- _{mean})	0.781	0.622	0.545	0.260	0.223	0.808	0.842	0.125	-0.164	-0.074	0.391
Ln(F _{Hd})	0.334	0.317	0.389	0.335	0.167	0.194	0.121	0.429	0.496	0.143	0.298
Ln(Q _{mean} /area)	-0.164	-0.133	-0.108	-0.080	-0.004	-0.219	-0.232	-0.403	0.202	-0.267	0.195
Ln(Q _{peak} /area)	0.098	0.021	0.018	-0.088	-0.009	0.168	0.197	-0.132	-0.389	-0.019	0.222
Ln(+ _{mean} /area)	-0.140	-0.074	-0.091	-0.123	0.003	-0.037	-0.038	-0.197	-0.402	0.214	-0.034
Ln(- _{mean} /area)	-0.316	-0.251	-0.238	-0.190	-0.030	-0.220	-0.192	-0.291	-0.441	0.153	-0.168

Appendix B – Correlation Matrix (cont.)

	BF ₁	BF ₂	BF ₃	F _{Ld}	F _{Ln}	F _{Hd}	F _{Hn}	Q _{mean} /area	Q _{peak} /area	Q ₅₀ /area	Q ₉₀ /area
A	0.185	0.095	0.054	0.185	-0.267	0.165	-0.367	-0.259	-0.299	-0.118	-0.218
IC	-0.825	-0.738	-0.673	-0.532	<i>0.570</i>	-0.666	0.906	0.277	0.279	0.207	0.143
WQ	0.863	0.800	0.759	0.387	-0.394	0.692	-0.904	-0.245	-0.586	0.018	0.378
AQL	0.629	0.579	0.556	0.059	-0.816	0.339	-0.573	-0.139	-0.274	0.287	0.141
Q _{peak}	0.066	-0.013	-0.050	0.028	-0.207	-0.009	-0.227	-0.170	0.000	-0.096	-0.168
Q _{mean}	0.230	0.154	0.113	-0.005	-0.297	0.095	-0.336	-0.060	-0.139	-0.061	-0.070
SD	0.075	-0.007	-0.046	0.003	-0.214	0.003	-0.247	-0.103	-0.033	-0.093	-0.143
COV	-0.592	-0.661	-0.682	0.064	0.224	-0.307	0.146	-0.302	0.360	-0.267	-0.442
Q ₅₀	0.303	0.277	0.268	-0.218	-0.339	-0.032	-0.167	0.123	-0.132	0.175	0.184
Q ₁₀	0.043	0.055	0.075	-0.349	<i>-0.401</i>	-0.227	0.158	-0.017	0.018	0.013	-0.030
Q ₉₀	0.371	0.296	0.252	0.088	-0.344	0.229	-0.435	-0.133	-0.261	-0.062	-0.052
Q _{mean+}	0.206	0.116	0.066	0.134	-0.216	0.162	-0.376	-0.099	-0.151	-0.086	-0.103
Q _{geommean}	0.272	0.195	0.154	0.140	-0.252	0.183	-0.337	-0.113	-0.217	-0.048	-0.046
Q _{mean(ln)}	0.274	0.218	0.178	0.248	-0.117	0.293	-0.380	-0.077	-0.157	-0.028	-0.017
SD _(ln)	0.125	0.105	0.080	0.263	0.345	0.276	-0.323	0.095	-0.141	0.066	0.085
COV _(ln)	0.004	0.004	-0.002	0.159	0.313	0.134	-0.150	0.088	-0.045	0.042	0.041
+ _{mean}	0.059	-0.042	-0.089	0.080	-0.163	0.014	-0.255	-0.166	-0.084	-0.103	-0.150
- _{mean}	-0.018	-0.110	-0.151	0.025	-0.135	-0.048	-0.181	-0.169	-0.046	-0.110	-0.175
T _{3XQ50}	0.080	0.000	-0.057	0.363	0.339	0.356	-0.424	-0.364	-0.239	-0.384	-0.297
T _{Omean}	0.858	0.874	0.869	0.131	-0.283	0.498	-0.509	0.362	-0.383	0.515	0.614
T _{dry}	-0.278	-0.326	-0.363	0.411	<i>0.669</i>	0.140	-0.114	-0.088	-0.050	-0.087	-0.112
T _{Q0.5-yr}	0.302	0.210	0.155	-0.067	-0.236	0.139	-0.378	0.156	0.048	0.104	0.357
BF ₁	---	0.981	0.956	0.319	<i>-0.537</i>	0.703	-0.729	0.012	-0.468	0.183	0.280
BF ₂	0.981	---	0.993	0.258	<i>-0.518</i>	0.661	-0.628	0.081	-0.445	0.225	0.332
BF ₃	0.956	0.993	---	0.219	<i>-0.518</i>	0.623	-0.561	0.108	-0.440	0.247	0.347
F _{Ld}	0.319	0.258	0.219	---	-0.179	0.617	-0.545	-0.208	-0.314	-0.106	-0.128
F _{Ln}	-0.537	-0.518	-0.518	-0.179	---	-0.315	0.383	0.131	0.195	0.032	0.054
F _{Hd}	0.703	0.661	0.623	0.617	-0.315	---	-0.791	-0.193	-0.497	-0.076	-0.026
F _{Hn}	-0.729	-0.628	-0.561	-0.545	0.383	-0.791	---	0.199	0.450	0.042	0.051
Q _{mean} /area	0.012	0.081	0.108	-0.208	0.131	-0.193	0.199	---	0.301	0.858	0.881
Q _{peak} /area	-0.468	-0.445	-0.440	-0.314	0.195	-0.497	0.450	0.301	---	0.065	0.149
Q ₅₀ /area	0.183	0.225	0.247	-0.106	0.032	-0.076	0.042	0.858	0.065	---	0.903
Q ₉₀ /area	0.280	0.332	0.347	-0.128	0.054	-0.026	0.051	0.881	0.149	0.903	---
Q _{mean} /area	-0.067	-0.008	0.010	-0.156	0.282	-0.183	0.192	0.968	0.332	0.789	0.831
Q _{mean(ln)} /area	0.179	0.212	0.225	-0.027	0.146	-0.015	-0.030	0.837	0.071	0.957	0.890
+ _{mean} /area	-0.588	-0.563	-0.545	-0.282	<i>0.531</i>	-0.509	0.514	0.471	0.571	0.339	0.373
- _{mean} /area	-0.662	-0.586	-0.543	-0.381	<i>0.551</i>	-0.600	0.713	0.493	0.562	0.333	0.372
ln(A)	0.319	0.217	0.168	0.282	-0.397	0.336	-0.544	-0.378	-0.388	-0.222	-0.340
ln(Q _{mean})	0.346	0.268	0.226	0.113	-0.415	0.236	-0.449	-0.064	-0.208	-0.021	-0.063
ln(Q _{peak})	0.101	0.001	-0.048	0.122	-0.331	0.082	-0.350	-0.267	0.028	-0.193	-0.295
ln(Q ₉₀)	0.544	0.475	0.431	0.133	-0.441	0.375	-0.538	-0.089	-0.275	-0.007	0.016
ln(+ _{mean})	0.015	-0.099	-0.152	0.166	-0.227	0.068	-0.326	-0.232	-0.087	-0.148	-0.254
ln(- _{mean})	-0.098	-0.194	-0.236	0.066	-0.175	-0.042	-0.186	-0.206	-0.029	-0.145	-0.259
ln(F _{Hd})	0.735	0.648	0.588	0.620	-0.372	0.891	-0.938	-0.238	-0.458	-0.083	-0.081
ln(Q _{mean} /area)	-0.077	0.006	0.039	-0.429	0.129	-0.323	0.399	0.739	0.493	0.464	0.654
ln(Q _{peak} /area)	-0.394	-0.421	-0.433	-0.134	0.017	-0.371	0.151	0.091	0.673	0.015	-0.075
ln(+ _{mean} /area)	-0.627	-0.620	-0.612	-0.285	<i>0.416</i>	-0.569	0.542	0.368	0.642	0.196	0.250
ln(- _{mean} /area)	-0.704	-0.649	-0.615	-0.421	<i>0.486</i>	-0.663	0.737	0.411	0.662	0.209	0.272

Appendix B – Correlation Matrix (cont.)

	$Q_{\text{mean}}/\text{area}$	$Q_{\text{mean}(\ln)}/\text{area}$	$+_{\text{mean}}/\text{area}$	$-_{\text{mean}}/\text{area}$	$\ln(A)$	$\ln(Q_{\text{mean}})$	$\ln(Q_{\text{peak}})$	$\ln(Q_{90})$	$\ln(+_{\text{mean}})$
A	-0.297	-0.104	-0.436	-0.488	0.817	0.713	0.741	0.646	0.696
IC	0.303	0.177	0.675	0.841	-0.566	-0.435	-0.469	-0.571	-0.275
WQ	-0.383	0.016	-0.630	-0.778	0.770	0.731	0.621	0.799	0.450
AQL	-0.666	-0.423	-0.671	-0.724	0.703	0.735	0.564	0.773	0.504
Q_{peak}	-0.194	-0.075	-0.245	-0.327	0.666	0.664	0.745	0.587	0.671
Q_{mean}	-0.097	-0.031	-0.264	-0.389	0.736	0.851	0.753	0.790	0.752
SD	-0.127	-0.069	-0.231	-0.333	0.692	0.745	0.757	0.653	0.718
COV	-0.250	-0.258	0.107	0.056	0.178	-0.028	0.368	-0.251	0.303
Q₅₀	0.025	0.120	-0.135	-0.236	0.406	0.587	0.420	0.564	0.436
Q₁₀	-0.117	-0.104	-0.079	-0.095	0.214	0.320	0.267	0.279	0.255
Q₉₀	-0.174	-0.024	-0.333	-0.454	0.757	0.843	0.713	0.842	0.725
Q_{mean+}	-0.081	-0.005	-0.212	-0.371	0.746	0.820	0.751	0.763	0.790
Q_{geomean}	-0.085	0.001	-0.154	-0.330	0.594	0.651	0.557	0.655	0.650
Q_{mean(ln)}	-0.031	0.137	-0.128	-0.266	0.530	0.588	0.499	0.595	0.567
SD_(ln)	0.183	0.279	0.054	-0.050	0.296	0.317	0.237	0.298	0.274
COV_(ln)	0.185	0.260	0.165	0.093	0.180	0.217	0.165	0.188	0.211
+_{mean}	-0.148	-0.039	-0.114	-0.292	0.713	0.750	0.760	0.662	0.810
-_{mean}	-0.157	-0.052	-0.102	-0.253	0.723	0.755	0.786	0.655	0.821
T_{3X050}	-0.210	-0.206	-0.126	-0.251	0.252	0.091	0.118	0.133	0.182
T_{QMean}	0.290	0.518	-0.272	-0.337	0.124	0.260	-0.058	0.465	-0.084
T_{drv}	0.114	0.090	0.288	0.191	-0.139	-0.313	-0.196	-0.338	-0.041
T_{Q0.5-yr}	-0.052	0.177	-0.160	-0.285	0.386	0.512	0.444	0.497	0.452
BF₁	-0.067	0.179	-0.588	-0.662	0.319	0.346	0.101	0.544	0.015
BF₂	-0.008	0.212	-0.563	-0.586	0.217	0.268	0.001	0.475	-0.099
BF₃	0.010	0.225	-0.545	-0.543	0.168	0.226	-0.048	0.431	-0.152
F_{Ld}	-0.156	-0.027	-0.282	-0.381	0.282	0.113	0.122	0.133	0.166
F_{Ln}	0.282	0.146	0.531	0.551	-0.397	-0.415	-0.331	-0.441	-0.227
F_{Hd}	-0.183	-0.015	-0.509	-0.600	0.336	0.236	0.082	0.375	0.068
F_{Hn}	0.192	-0.030	0.514	0.713	-0.544	-0.449	-0.350	-0.538	-0.326
Q_{mean}/area	0.968	0.837	0.471	0.493	-0.378	-0.064	-0.267	-0.089	-0.232
Q_{peak}/area	0.332	0.071	0.571	0.562	-0.388	-0.208	0.028	-0.275	-0.087
Q₅₀/area	0.789	0.957	0.339	0.333	-0.222	-0.021	-0.193	-0.007	-0.148
Q₉₀/area	0.831	0.890	0.373	0.372	-0.340	-0.063	-0.295	0.016	-0.254
Q_{mean+}/area	---	0.822	0.575	0.563	-0.409	-0.108	-0.291	-0.134	-0.215
Q_{mean(ln)}/area	0.822	---	0.405	0.363	-0.190	0.006	-0.165	0.032	-0.091
+_{mean}/area	0.575	0.405	---	0.893	-0.524	-0.324	-0.267	-0.378	-0.092
-_{mean}/area	0.563	0.363	0.893	---	-0.693	-0.520	-0.464	-0.563	-0.349
ln(A)	-0.409	-0.190	-0.524	-0.693	---	0.901	0.897	0.827	0.873
ln(Q_{mean})	-0.108	0.006	-0.324	-0.520	0.901	---	0.887	0.935	0.881
ln(Q_{peak})	-0.291	-0.165	-0.267	-0.464	0.897	0.887	---	0.770	0.928
ln(Q₉₀)	-0.134	0.032	-0.378	-0.563	0.827	0.935	0.770	---	0.752
ln(+_{mean})	-0.215	-0.091	-0.092	-0.349	0.873	0.881	0.928	0.752	---
ln(-_{mean})	-0.193	-0.092	-0.051	-0.247	0.840	0.859	0.919	0.713	0.979
ln(F_{Hd})	-0.225	-0.003	-0.519	-0.690	0.520	0.405	0.309	0.519	0.285
ln(Q_{mean}/area)	0.727	0.442	0.584	0.602	-0.589	-0.180	-0.383	-0.133	-0.339
ln(Q_{peak}/area)	0.124	0.026	0.445	0.295	0.017	0.098	0.355	-0.013	0.319
ln(+_{mean}/area)	0.460	0.229	0.912	0.807	-0.515	-0.299	-0.208	-0.373	-0.031
ln(-_{mean}/area)	0.484	0.221	0.879	0.925	-0.697	-0.492	-0.407	-0.552	-0.284

Appendix B – Correlation Matrix (cont.)

	$\ln(-\text{mean})$	$\ln(F_{Hd})$	$\ln(Q_{\text{mean}}/\text{area})$	$\ln(Q_{\text{peak}}/\text{area})$	$\ln(+\text{mean}/\text{area})$	$\ln(-\text{mean}/\text{area})$
A	0.700	0.323	-0.524	-0.025	-0.450	-0.550
IC	-0.108	-0.859	0.403	0.288	0.606	0.780
WQ	0.284	0.827	-0.253	-0.539	-0.558	-0.737
AQL	0.437	0.424	-0.160	0.011	-0.545	-0.624
Q_{peak}	0.690	0.157	-0.273	0.189	-0.184	-0.291
Q_{mean}	0.751	0.274	-0.084	0.110	-0.187	-0.338
SD	0.733	0.175	-0.181	0.174	-0.155	-0.282
COV	0.337	-0.195	-0.455	0.453	0.168	0.123
Q_{50}	0.421	0.095	0.172	0.052	-0.066	-0.178
Q_{10}	0.288	-0.186	0.112	0.127	0.010	-0.005
Q_{90}	0.709	0.397	-0.146	0.014	-0.277	-0.431
$Q_{\text{mean}+}$	0.781	0.334	-0.164	0.098	-0.140	-0.316
Q_{geommean}	0.622	0.317	-0.133	0.021	-0.074	-0.251
$Q_{\text{mean}(\ln)}$	0.545	0.389	-0.108	0.018	-0.091	-0.238
$SD_{(\ln)}$	0.260	0.335	-0.080	-0.088	-0.123	-0.190
$COV_{(\ln)}$	0.223	0.167	-0.004	-0.009	0.003	-0.030
+mean	0.808	0.194	-0.219	0.168	-0.037	-0.220
-mean	0.842	0.121	-0.232	0.197	-0.038	-0.192
T_{3XQ50}	0.125	0.429	-0.403	-0.132	-0.197	-0.291
$T_{Q\text{mean}}$	-0.164	0.496	0.202	-0.389	-0.402	-0.441
T_{dry}	-0.074	0.143	-0.267	-0.019	0.214	0.153
$T_{0.5\text{-yr}}$	0.391	0.298	0.195	0.222	-0.034	-0.168
BF_1	-0.098	0.735	-0.077	-0.394	-0.627	-0.704
BF_2	-0.194	0.648	0.006	-0.421	-0.620	-0.649
BF_3	-0.236	0.588	0.039	-0.433	-0.612	-0.615
F_{Ld}	0.066	0.620	-0.429	-0.134	-0.285	-0.421
F_{Ln}	-0.175	-0.372	0.129	0.017	0.416	0.486
F_{Hd}	-0.042	0.891	-0.323	-0.371	-0.569	-0.663
F_{Hn}	-0.186	-0.938	0.399	0.151	0.542	0.737
$Q_{\text{mean}}/\text{area}$	-0.206	-0.238	0.739	0.091	0.368	0.411
$Q_{\text{peak}}/\text{area}$	-0.029	-0.458	0.493	0.673	0.642	0.662
Q_{50}/area	-0.145	-0.083	0.464	0.015	0.196	0.209
Q_{90}/area	-0.259	-0.081	0.654	-0.075	0.250	0.272
$Q_{\text{mean}+}/\text{area}$	-0.193	-0.225	0.727	0.124	0.460	0.484
$Q_{\text{mean}(\ln)}/\text{area}$	-0.092	-0.003	0.442	0.026	0.229	0.221
+mean/area	-0.051	-0.519	0.584	0.445	0.912	0.879
-mean/area	-0.247	-0.690	0.602	0.295	0.807	0.925
$\ln(A)$	0.840	0.520	-0.589	0.017	-0.515	-0.697
$\ln(Q_{\text{mean}})$	0.859	0.405	-0.180	0.098	-0.299	-0.492
$\ln(Q_{\text{peak}})$	0.919	0.309	-0.383	0.355	-0.208	-0.407
$\ln(Q_{90})$	0.713	0.519	-0.133	-0.013	-0.373	-0.552
$\ln(+\text{mean})$	0.979	0.285	-0.339	0.319	-0.031	-0.284
$\ln(-\text{mean})$	---	0.150	-0.303	0.323	0.000	-0.196
$\ln(F_{Hd})$	0.150	---	-0.426	-0.180	-0.566	-0.741
$\ln(Q_{\text{mean}}/\text{area})$	-0.303	-0.426	---	0.143	0.611	0.663
$\ln(Q_{\text{peak}}/\text{area})$	0.323	-0.180	0.143	---	0.526	0.396
$\ln(+\text{mean}/\text{area})$	0.000	-0.566	0.611	0.526	---	0.930
$\ln(-\text{mean}/\text{area})$	-0.196	-0.741	0.663	0.396	0.930	---