Research Technical Completion Report

USE OF MULTIVARIATE MODELING TO ESTIMATE IMPACTS OF GROUNDWATER WITHDRAWALS ON STREAMFLOW FOR THE CAMAS CREEK BASIN

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ABSTRACT

The conjunctive use of surface and groundwater has been recognized as posing significant water rights issues in many of the Idaho river basins. Increases in groundwater pumping rates, primarily for irrigation, have led to changes in surface streamflow, affecting previously allocated surface water rights. However, the magnitude of this effect and its variability over time remain difficult to estimate.

The primary objective of this study was to develop a multivariate monthly flow model for Camas Creek, based on stream flows in neighboring basins, and to test whether such a model is sensitive enough to detect, at some statistical level of significance, any streamflow changes that may have resulted from groundwater withdrawals.

Monthly streamflow records from Camas Creek and three similar neighboring basins were used to develop a multivariate monthly streamflow model of Camas Creek. Model parameters were based on the recorded statistics for the record period common to groundwater development within the Camas Creek basin. The model was developed and tested for its ability to adequately reproduce the historic pre-irrigation time series for Camas Creek. Then the model was applied to the time period in which significant groundwater withdrawals occurred. A comparison of the modeled streamflow with the actual flows for this period was used to estimate the impacts of groundwater pumping on monthly, seasonal, and annual streamflows. The differences between the two time series were related to the history of groundwater development within the basin.

Although the model appeared to simulate the overall historic time series reasonably well, its performance varied by month and season.

The application of the model to the time period in which the Camas Creek basin groundwater withdrawals were significant produced a simulated record with lower streamflows than those observed. This may be attributable to the fact that most of the large wells have pumped from deep aquifers, with no connection to the surface stream system.

CHAPTER 1

INTRODUCTION

1. Background

The conjunctive use of surface and groundwater has posed significant water rights issues in many Idaho river basins. Increases in groundwater pumping rates, primarily for irrigation, have led to changes in surface streamflow, and have caused concerns over the impacts of the reduction on previously allocated surface water rights. However, the magnitude of this effect and its variability over time remain difficult to estimate, resulting in very real problems associated with current and future planning, as well as management of the State's water resources.

Although this problem can be addressed by detailed deterministic hydrologic modeling of surface and subsurface flows in a particular basin, the application of such models is an expensive and time-consuming process, and their accuracy is often dependent upon extensive input data requirements. Therefore, other procedures that offer the possibility of quantifying pumping impacts on surface water flows, without the cost and time requirements of basin modeling, are certainly needed. Such procedures could be used to identify those basins where a clear pumping impact exists; to screen candidate basins for further, more detailed, studies; and to guide future decisions related to allocation of surface and groundwater rights. If such procedures can be shown to be effective, then they have the potential to be used by the Idaho Department of Water Resources in the conjunctive management of the State's surface and groundwater resources. They may also be used as technical inputs to administrative or judicial proceedings related to future water rights issues.

2. Nature and Scope of Research Project

In general, this study tests the applicability of multivariate streamflow models to the detection and quantification of groundwater pumping effects on surface water flow rates. The application was limited to one particular basin, Camas Creek in Camas County, Idaho, where groundwater use for irrigation is currently substantial. By establishing a multivariate stochastic relationship between the natural flow rates (prior to extensive groundwater development) on Camas Creek and the flow rates on adjacent basins, a comparison was made between the observed and estimated flows for the period when groundwater withdrawal was significant. This comparison indicates, quantitatively, the impacts of groundwater pumping on the surface flow regime for Camas Creek.

More specifically, a multivariate model was developed to permit the estimation of monthly flows on Camas Creek by the use of the monthly flow series on nearby basins. This model was based on time-series for all the stations during the historical period before the Camas Creek basin was extensively pumped. Since the adjacent basins to be used in this study have never experienced substantial groundwater development, their more recent flow records can be used to generate a synthetic record for Camas Creek that represents natural (unpumped) conditions.

By a detailed comparison and analysis of the synthetic and observed time-series for Camas Creek, several critical observations can be made relative to general model performance and the specific effects of groundwater use within this basin :

1. Statistical tests applied to the difference between two time-series, to indicate whether or not the procedure can establish a significant link between groundwater withdrawal and impacts on streamflow.
2. Monthly and seasonal differences in the time series, to see how these are related to the seasonal distribution of irrigation pumping.
3. Tests for trends in streamflow change, to indicate whether the basin has established an "equilibrium" condition.
4. Examination of the time-history of well development and comparison to the annual differences between the two flow series, to obtain information concerning the time lag between well development and impacts on the Camas Creek streamflow.
5. Comparisons between total number of wells (and estimated withdrawal, if possible) and annual differences (time-lagged, if necessary) to indicate whether this relationship is affected by "wet" or "dry" year conditions.
6. Cumulative differences between the time series, to provide a measure of the total volumetric effects of pumping (total historic streamflow change).

These and other similar observations provide valuable insights into the nature of streamflow alterations Camas Creek as a result of extensive groundwater pumping within the basin.

3. Specific Research Objectives

The specific research objectives of this proposed project include:

1. To develop a multivariate monthly flow model for Camas Creek that can be used to estimate the streamflow that might have

occurred if the basin had not experienced groundwater withdrawal.

2. To test whether such a model is sensitive enough to detect, at some statistical level of significance, appreciable streamflow changes that may have resulted from pumping.
3. To determine, if these changes are significant, the quantitative effects of the pumping on the surface water flow. These effects will include:
   * Annual flow changes
   * Trends or behavior in these changes
   * Monthly and seasonal impacts
4. To establish, if possible, the relationship between any observed effects and the history of groundwater development within the basin.
5. To estimate the effects of future year drought conditions, coupled with current pumping rates, on Camas Creek flows.
6. To suggest other candidate basins where this or similar procedures may be used to investigate the impacts of groundwater withdrawals on surface streamflow.

The tasks, methodologies and results related to these objectives are fully described in the following chapters of this report.

CHAPTER 2

STUDY STREAM SELECTION AND INITIAL DATA ANALYSIS

1. Selection of Streamflow Records

Development of a multivariate stochastic model to find the impacts of groundwater pumping on the surface water flow requires one "key" station and one or more subordinate stations. The basin of the "key" station should use a substantial amount of groundwater for irrigation. The "key" station and the subordinate stations data should be of good quality, with a sufficiently large sample size to adequately define the sample statistics and to meet parameter parsimony restrictions during modeling. In addition, the data of the subordinate stations should be reasonably free of the effects of pumping and/or storage regulation. The drainage area of each subordinate station should be similar to the drainage area of the "key" station. Based on these considerations, the following criteria and constraints were established to select the "key" station and subordinate stations:

1. Each record should consist of at least 40 years of data in order to help reduce the uncertainty associated with the estimates of the model parameter (parameter parsimony).
2. Each subordinate station record should represent natural conditions. In other words, there should be a minimal amount of pumping and/or storage regulation.
3. Each record should be described by the U. S. Geological Survey as at least "fair" over its entire length.
4. The drainage area of each subordinate basin should not differ from the key station by more than 100 %.

5. The hydrologic regimes of the subordinate stations should be as similar as possible to those of the "key" station.

HISARS (47) and The Water Resources Data Publication for Idaho (48) were reviewed, keeping in mind the established criteria and constraints. To select the "key" station for Camas Creek basin, the above applicable criteria and constraints were considered. It was concluded that the Camas Creek station (13.1415.00) is the only possible " key " station to meet the criteria and constraints. Therefore, station 13.1415.00 was chosen as the " key " station in this study. More details for this station are found in Appendix A, Table A.1.

As candidates for the subordinate stations, five stations were found to meet the first three selection criteria as stated above; and these stations are listed in Appendix A, Table A.1. The application of the above last two criteria resulted in the elimination of two stations (13.0830.00 and 13.1200.00). This resulted in one " key " station and three subordinate stations listed in Table 2.1. The locations of the streamflow stations are illustrated in Fig.2.1. The Camas Creek Basin map is in Fig.2.2.

Table 2.1: Streamflow Records

Gage Location (USGS No.)	Drainage Area	Period of Record (Partial Record)
Camas Creek at Blaine (13.1415.00)	648 mi^2	1925 - 1985 (1925 - 1944)
Big Wood Slough at Hailey (13.1395.10)	640 mi^2	1925 - 1973
Big Lost River at Chilly (13.1205.00)	450 mi^2	1925 - 1985 (1925 - 1948)
Goose Creek at Oakley (13.0825.00)	633 mi^2	1925 - 1985 (1984)

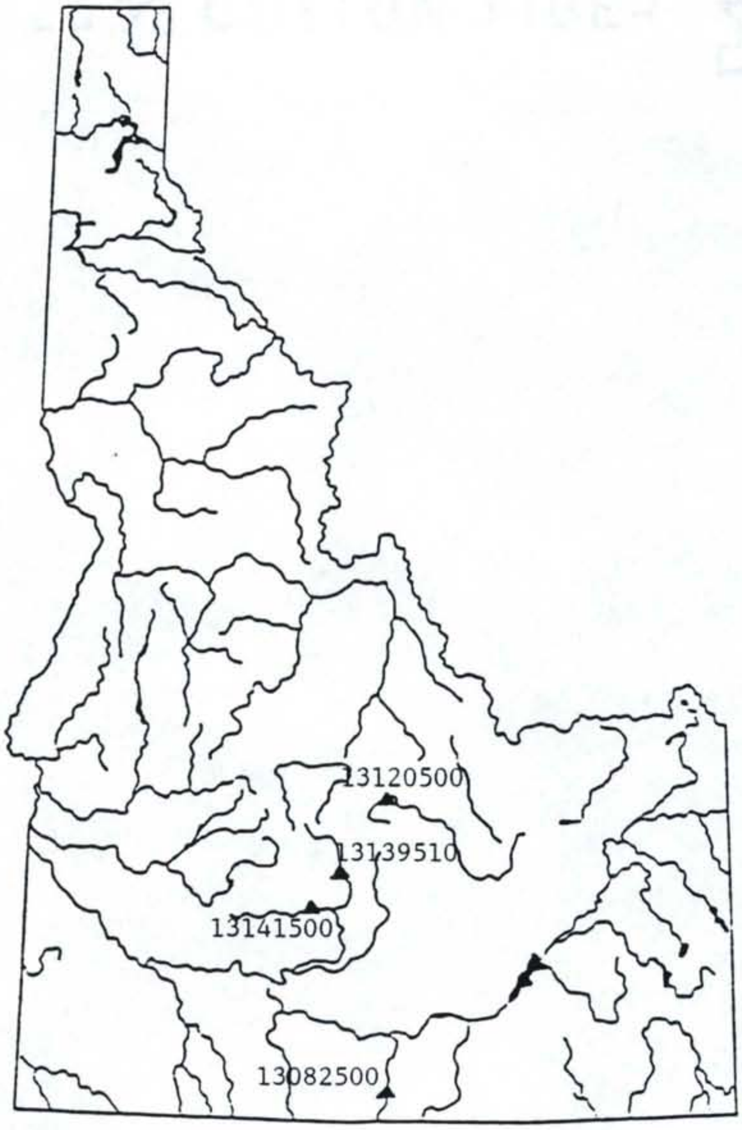


Fig. 2.1 Location of Streamflow Stations

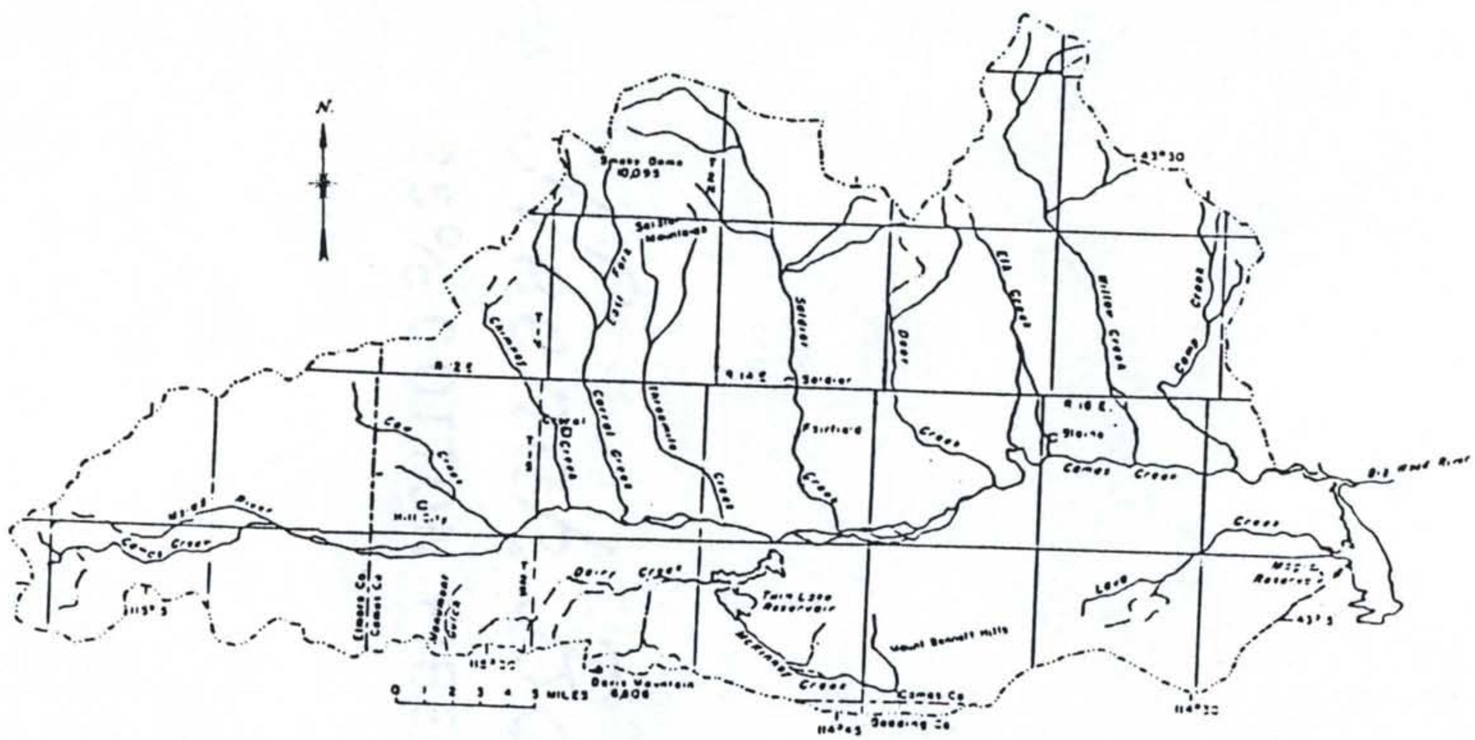


Fig. 2.2 Camas Creek Basin

2. Initial Data Analysis

Using the data summary routines in HISARS, the flow records (stored in HISARS as daily values) were accessed for the four stations and aggregated for each station to process a file of monthly flow values. For any station, if the flow records were incomplete during a particular water year, those "monthly" values were treated as "missing data" that could eventually be filled in utilizing a data augmentation analysis.

Although three gages (Camas Creek, Big Lost River, Goose Creek) showed a common period of 1925 to 1985 water years, Big Wood Slough gage showed a common period of 1925 to 1973. Fortunately, the Big Wood River station (13.1395.00), which has a complete record of 1961-1985 water years, has been moved from the Big Wood Slough at Hailey station (13.1395.10).

Using the relationship of the overlapping period between the streamflow records of the old station (13.1395.10) and those of the new station (13.1395.00), the streamflow records of 1974-1985 water years for the Big Wood Slough at Hailey Station (13.1395.10) were easily estimated (see the following chapter). Therefore, a common period of records encompasses 61 years (1925-1985 water years) for all four gages. A listing of the monthly streamflow records used in the initial step can be found in Appendix B , Tables B.1 through B.4.

Annual groundwater bulletins, published by the Idaho Department of Reclamation, Department of Water Resources, and the Geological Survey were reviewed to obtain a chronological history of well development in the Camas Creek basin. Table Q.1, Appendix Q shows the logs of irrigation wells in the study area.

CHAPTER 3

DATA AUGMENTATION

1. Big Wood Slough (13.1395.10)

Big Wood Slough station (13.1395.10) has a complete period of record from 1925 to 1973, and therefore data augmentation was required for 1974-1985. Trials to find a long-term key station that could be used to extend the data at the subordinate station (13.1395.10) were conducted. Review of Water Resources Data for Idaho(48) showed that the Big Wood River station (13.1395.00) has been moved from the Big Wood Slough station (13.1395.10). Big Wood River station (13.1395.00) has a complete record period of 1961-1985, and the two gages have a 13 year overlap period. Because the two streamflow records show a high linear relationship (Table C.1), a simple linear regression model was selected to fill in 1974-1985 records of Big Wood Slough station (13.1395.10).

1.1 Model Description: Generally, the objective of a simple linear regression model is to provide a means of predicting or estimating one variable, the dependent variable, from knowledge of a second variable, the independent variable. This regression model considers only a spatial correlation coefficient, ignoring any serial correlation coefficients, and no special constraints are associated with this model. A simple linear regression can be expressed as equations 3.1-3.4:

$$Y_\tau = \alpha_\tau + \beta_\tau X_\tau + \varepsilon_\tau \tag{3.1}$$

$$\beta_\tau = \frac{\mathrm{cov}\left(Y_\tau, X_\tau\right)}{S^2_{x\tau}} \tag{3.2}$$

$$\alpha_\tau = Y_\tau - \beta_\tau X_\tau - \varepsilon_\tau \tag{3.3}$$

$$\varepsilon_\tau = Z_\tau S_{y\tau}\left(1 - R_\tau^2\right) \tag{3.4}$$

where:

τ	=	month
Y	=	monthly streamflow value at subordinate station
X	=	monthly streamflow value at key station
ε_τ	=	residual series
$S_{x\tau}$	=	standard deviation of key station records
$S_{y\tau}$	=	standard deviation of subordinate station records
R_τ^2	=	coefficient of determination

The parameters (α_τ, β_τ, R_τ^2) were calculated for each month and are listed in Appendix C, Table C.1.

1.2 Results: Using the parameters and equations 3.1-3.4, the 1974-1985 water year records of the Big Wood Slough (13.1395.10) were estimated. These results are provided as Table D.1 in Appendix D.

2. Goose Creek (13.0825.00)

The monthly records of Goose Creek in HISARS have one missing month (January, 1984). Contact with the USGS to obtain the missing data information resulted in a complete record covering the period of 1925 to 1985 at Goose Creek. In addition, the Goose Creek monthly record has two months with zero flows (September, 1935 and August, 1940). A minimum value of 1 cfs-day was used to permit a possible log-transformation of the multisite model. The results are in Appendix D, Table D.3.

3. Big Lost River (13.1205.00)

The Big Lost River station (13.1205.00) has a partial record from 1925 to 1948 in the winter months (November through April), and it was therefore necessary to determine a key station that could be used to fill in these missing records. This key station record should overlap the subordinate station record by as much as possible to provide the most reliable estimate of the correlation between the two records. Trials to find a key station which had at least a 20 year overlap period and a high spatial correlation with Big Lost River were conducted. The results (Table E.1) showed Big Wood Slough (13.1395.10) was the only available pairing station, considering criteria such as overlapping record length, correlation, and location. Two modeling processes were considered to fill in partial records of the Big Lost River station (13.1205.00). One was a multivariate AR(1) model approach; the other was a disaggregation model application. These two modeling processes are described in the following sections.

3.1 Multivariate AR(1) Model Approach: Autoregressive models of order p, denoted by AR(p), have been extensively used in hydrology and water resources since the early 1960's for modeling annual and periodic hydrologic time series. The application of these models has been attractive in hydrology mainly because the autoregressive form has an intuitive type of time dependence (the value of a variable at the present time depends on the values at previous times), and they are very simple models to use. It is assumed that AR(p) models preserve in the statistical sense the historical mean, standard deviation and the first p serial correlation coefficients.

The simplest autoregressive model is an AR(1) or first-order autoregressive model. This model regresses flow in time period t against flow in period t-1. AR(1) models are based on normal time series and most of the goodness-of-fit tests are also based on the normality of the series analyzed. Therefore, before the model parameters of the AR(1) model can be determined, the assumption of the normality of the AR(1) model should be examined.

The simple AR(1) model considered so far deals with streamflows for a single site. Several new problems arise in the streamflow generation when several sites are used. It is not satisfactory simply to use single site generation procedures for each of the sites in turn, because streamflows at various sites can be strongly interrelated. Independent generation of the streamflow values for multiple sites cannot preserve spatial and temporal correlations between streamflows; consequently, multivariate techniques are needed to preserve the spatial and time dependence (32,42). Therefore, a multivariate AR(1) model has the property to preserve the historical means, standard deviations, lag-zero and the lag-one cross-correlation and the lag-one autocorrelation.

a) Preliminary Analysis: Before beginning the data augmentation process, the normality of each monthly series was tested, since this is a critical model assumption. The hypothesis that the skew coefficient is not significantly different from zero was tested using approximate 95 % confidence limits around a g = 0 value:

$$g(95\,\%) = 0 \pm 1.96\,(6/n)^{1/2} \qquad (3.5)$$

where:

$g(95\ \%)$ = limit for coefficient of skew equal to zero

n = number of monthly values.

The test for normality of the key station (13.1395.10) showed normality for October through February and June flows. The months of March, April, May, July, August, and September flows were found to be log-normal and were transformed by using a log-transformation:

$$Y_\tau = \log(X_\tau) \qquad (3.6)$$

where:

τ = month

Y_τ = transformed monthly streamflow value

X_τ = raw monthly streamflow value

The test results for normality for the key station (13.1395.10) are shown in Appendix F, Table F.1. The tests for normality of the subordinate station (13.1205.00) showed normality for October through March and June flows. The months of April, May, July, August, and September flows can again be log-transformed. These results are shown in Appendix F, Table F.2. Because several of the monthly streamflows of the subordinate station were extremely high in the 1984-1985 water year, these records were considered as outliers for the normality analysis. After conducting log-transformations for the two stations, the test for normality of the common period between the key station and subordinate station also showed normality. Results are provided in Appendix F, Table F.3.

b) Estimation of Parameters: The AR(1) model (lag-one multivariate autoregressive model) of the standardized annual monthly series $Z_v^{(i)}$, i = 1,2,... n can be represented in matrix form by:

$$Z_v = A_1 Z_{v-1} + B\varepsilon_v \tag{3.7}$$

where:

Z_v = nx1 vector of elements Z_v

A_1 and B = nxn matrix parameters

ε_v = nx1 vector of independent, normally distributed random variable with mean zero and variance one

v = current year

Using the representation of equation 3.7, the AR(1) model having one key station and one subordinate station can be presented as follows:

$$Z_v^{(1)} = a^{11}Z_{v-1}^{(1)} + a^{12}Z_{v-1}^{(2)} + b^{11}\varepsilon_v^{(1)} + b^{12}\varepsilon_v^{(2)} \tag{3.8}$$

$$Z_v^{(2)} = a^{21}Z_{v-1}^{(1)} + a^{22}Z_{v-1}^{(2)} + b^{21}\varepsilon_v^{(1)} + b^{22}\varepsilon_v^{(2)} \tag{3.9}$$

where the a's and b's are the elements of the estimated matrix parameters, A_1 and B, respectively, and $\varepsilon_v^{(1)}$ and $\varepsilon_v^{(2)}$ are independent and identically distributed normal variables with mean zero and variance one. For the AR(1) model of equation 3.7 the moment estimates of the parameters A_1 and B were obtained from:

$$A_1 = M_1 M_0^{-1} \tag{3.10}$$

$$BB^T = M_0 - A_1 M_1^T = D \tag{3.11}$$

where M_0 and M_1 are the lag-zero and lag-one correlation matrices of Z_v (42). A_1 and BB^T were obtained from equations 3.10 and 3.11. Matrix B was obtained from the matrix $BB^T = D$. If B is a lower triangular matrix and D is a positive definite matrix, then non-zero elements of B may be determined by:

$$b^{ij} = d^{ji} / b_{ij} \text{ , for } j = 1, i = 1,...,n, \tag{3.12}$$

$$b^{ij} = \left[d^{ij} - \sum_{k=1}^{j-1} \left(b^{jk}\right)^2 \right]^{1/2} \text{ , for } j = 2, \ldots, n, \; i = j \tag{3.13}$$

$$b^{ij} = \left[d^{ij} - \sum_{k=1}^{j-1} b^{jk} b^{ik} / b^{ij} \right] \text{ , for } j = 2, \ldots n\text{-}1, \; i = j\text{+}1, \ldots, n \tag{3.14}$$

where b^{ij} are the elements of B, d^{ij} are the elements of D and n is the size of the matrices B and D (44). The estimation of parameters of the model requires the solution of the matrix equation $BB^T = D$. That is, determine the elements of a matrix B such that the product of B times its transpose B^T is equal to D. Therefore, the a's and b's of the equation 3.8 and 3.9 were obtained by the estimated matrix parameters A_1 and B, respectively.

In order to estimate the parameters of this model, monthly sample means and standard deviations for both stations were obtained. Using these statistics, the standardized annual monthly series, $Z_v^{(i)}$, were determined. The correlation matrices, M_0 and

M_1 were determined from the lag-zero and lag-one correlation matrices of $Z_v^{(i)}$. Frequently, when transformed series are modeled, the statistics of the transformed series (Y) are preserved; but once the inverse transform is applied and the actual series examined, the historical (untransformed) statistics are not preserved. This problem has prompted the development of formulas for the logarithmic transform which relate the moments of the historical record (X) to those of the transformed record (Y) (42,43). Use of these relationships helps to preserve the actual historical correlation coefficients. These relationships for the logarithmic transform are listed below and were used to determine the statistics of the transformed series that, in turn, were used in estimating the parameters for the multivariate model:

If $Y_{\tau-1} = \log(X_{\tau-1})$ and $Y_\tau = \log(X_\tau)$

$$r_{x,\tau}=\frac{\exp\left(S_{y,\tau-1}S_{y,\tau}r_{y,\tau}\right)-1}{\left[\exp\left(S_{y,\tau-1}^{2}\right)-1\right]^{1/2}\left[\exp\left(S_{y,\tau}^{2}\right)-1\right]^{1/2}} \qquad (3.15)$$

if $Y_{\tau-1} = \log(X_{\tau-1})$ and $Y_\tau = X_\tau$

$$r_{y,\tau}=\frac{\left[r_{x,\tau}\exp\left(S_{y,\tau-1}^{2}\right)-1\right]^{1/2}}{S_{y,\tau-1}} \qquad (3.16)$$

if $Y_{\tau-1} = X_{\tau-1}$ and $Y_\tau = \log(X_\tau)$

$$r_{y,\tau}=\frac{r_{x,\tau-1}\left[\exp\left(S_{y,\tau}^{2}\right)-1\right]^{1/2}}{S_{y,\tau}} \qquad (3.17)$$

where:

Y = transformed monthly streamflow values

X = raw monthly streamflow values

S_y = standard deviation of transformed monthly streamflows

r_x = correlation coefficient between raw monthly streamflows

r_y = correlation coefficient between transformed months

τ = month

c) Model Application: The model was applied to fill in the missing monthly records of the Big Lost River station (13.1205.00) using the estimates obtained from the relationship of the 25 years of common record (1949-1973) between the key station (13.1395.10) and the subordinate station. Using the annual monthly multivariate AR(1) model, the monthly data of the 1925-1948 water years for the Big Lost River were generated. However, when filling in the missing monthly flows, if the actual monthly data existed for 1925-1948, the generated values were disregarded, and instead the actual values were used. These filled in monthly records were summed to form annual records. These annual records were compared with the annual flows generated by the annual multivariate AR(1) modeling. The difference between the two annual time series (one was the sum of the monthly flows by the annual monthly multivariate AR(1) modeling, the other was the annual flows by the annual multivariate AR(1) modeling) of the each year for the 1925-1948 water years was calculated and the results are shown in Appendix G, Table G.6.

d) Comparisons of Simple Statistics: After filling in data for the missing monthly records (November through April) by the multivariate AR(1) model, the simple statistics (mean, standard deviation, skew coefficient) were compared between the original monthly data of the 1949-1985 for November through April and the filled-in monthly data of the 1925-1985 for November through April. However, since the monthly records of the 1984-1985 water years were considered as outliers in the statistical analyses, these monthly values were excluded from the comparisons (Table F.4). The comparisons show that the simple statistics of the filled-in record appear not to be substantially different from those of the original record on the Big Lost River station (13.1205.00). The results of the monthly simple statistics comparisons between original and filled-in streamflows for station 13.1205.00 are shown in Appendix F, Table F.4.

Although the annual monthly multivariate AR(1) model worked well, as an alternative approach, the following disaggregation model was tried to fill in the missing monthly records of the Big Lost River, and then the performances of the both models for this particular data were examined.

3.2 Disaggregation Model Approach: Traditionally, synthetic stream flow records have been generated by models designed to preserve the statistics at one time level. For example, synthetic monthly streamflow records have often been generated by models developed from and designed to preserve the historical monthly record. Experience has shown that if each year's monthly flows are summed to form an annual series, the statistics of the generated annual series do not necessarily resemble the statistics of the historical annual record. This is because any modeling errors, whether due to unreasonable assumptions (i.e, linear correlation, normality, etc.) or poor parameter estimates are concentrated into the resulting annual series.

Disaggregation models are designed to overcome the inconsistencies of the above by generating time series at different time levels (36). Therefore, a disaggregation model is a process by which a key series (annual flows) is broken apart into subseries (monthly flows) which are then summed to obtain the key series values. The key series could itself have been generated previously by a multivariate stochastic model designed to preserve its statistics. Then, generation of the subseries is accomplished by using a multivariate stochastic model designed to preserve the important statistical properties of not only the subseries itself, but also of the linear relationships between the key and subseries values. In this manner, statistical properties are preserved at both key and subseries levels and the relationships between the two levels are maintained. The annual records (sum of the monthly records) with partial monthly records of 1925-1948 for the Big Lost River station (13.1205.00) can be regarded as missing annual records. To fill in these missing annual records of 1925-1948, a multivariate AR(1) model with the form of equation 3.7 was applied.

a) Model Selection and Assumption: Lane's disaggregation model (45) was used in this study because of the ease of parameter estimation and the limited number of parameters. Lane's model for an annual to monthly disaggregation can be written as:

$$J_{\tau,\nu} = Q_\tau Y_\nu + G_{\tau,\nu}\lambda_{\tau,\nu} + H_{\tau,\nu}J_{\tau-1,\nu} \quad \text{(for } \tau = 1 \text{ to } 12) \tag{3.18}$$

where:

J_τ = standardized, normalized monthly streamflow value (if $\tau = 1$ then τ-1 = 12 and $\nu = \nu$-1)

Y = pre-existing normalized, standardized annual value corresponding to same year as monthly J value

λ = random deviate

t = current month

ν = year

Q,G,H = monthly model parameters

This model is designed to preserve the linear cross correlation between annual and monthly values, along with the lag-one correlations, variances and means of the annual and monthly values. In order to use this model, the parameters Q, G, and H of equation 3.16 first must be estimated for each month of the time series. For a one-station temporal model using normalized and standardized sequences, the parameters can be estimated as follows:

$$Q_\tau = \frac{r_{yj,\tau} - r_{j,\tau} r_{yj,\tau-1}}{1 - r_{yj,\tau-1}^{2}} \tag{3.19}$$

$$H_\tau = r_{j,\tau} - Q_\tau r_{yj,\tau-1} \tag{3.20}$$

$$G_\tau G_\tau^T = 1 - Q_\tau r_{yj,\tau} - H_\tau r_{j,\tau} \tag{3.21}$$

where:

$r_{yj,\tau}$ = correlation coefficient between each month and corresponding annual value

$r_{j,\tau-1}$ = correlation coefficient between previous monthly value and corresponding yearly value

$r_{j,\tau}$ = lag one serial correlation coefficient between monthly value

τ = month

b) Normality of Monthly Streamflow Records: The annual series (key) for the 1949-1983 water years were found to approximate a normal distribution. Hence, only the monthly series (subseries) for the same period (1949-1983) were further examined for normality. The normality of each monthly series was checked by determining if the coefficient of skewness for each series was statistically different from zero. Equation 3.5 gives the bounds for a coefficient of skewness equal to zero at the 5 % significance level. Therefore, if the coefficient of skewness of a monthly series fell within the 95 % limits, the series was considered normal. The results of this test for normality are summarized in Appendix G , Table G.1. From Table G.1, it can be seen that the assumption of normality was not valid for many of the untransformed monthly series. It is necessary to find an appropriate transformation that will convert the skewed sequences into normally distributed sequences. To do this, transformed sequences must be used for model generation and the inverse transform applied to obtain the actual streamflow values. This procedure was followed because it was recommended by Lane (45) when presenting his model.

c) Lognormal Transformation: A lognormal transform was used to reduce the skewness of the time series, as was previously described in equation 3.6. Equations 3.15 through 3.17 were used to preserve the actual historical correlation coefficients for the logarithmic transformation series. The series corresponding to the skew coefficients in Table G.1 marked with an " * " were used for modeling. Based on the transformation selected in Table G.1 for each monthly series, the appropriate relationships (equations 3.15 through 3.17) were solved to obtain the correlation coefficients of the transformed sequences. The results are listed in Appendix G, Table G.2.

d) Standardizing Monthly Streamflow Values: Lane's model also assumes that the means of the normally distributed series are equal to zero. This assumption was satisfied by subtracting the means of the monthly untransformed/transformed series (listed in Table G.2). In addition, each transformed value was divided by its transformed standard deviation (Table G.2) to create standardized series. Equation 3.22 illustrates the steps taken to arrive at the series actually used in modeling for the transformed series:

$$Z = \frac{\log(x) - \bar{y}}{S_y} \tag{3.22}$$

where:

- Z = normally distributed monthly streamflow value with mean of zero and standard deviation of one
- x = historical monthly streamflow value, except for months where log(x) would be replaced simply by x
- $\bar{y}$ = mean of transformed series
- S_y = standard deviation of transformed series

e) Monthly/Annual Correlation Coefficients: In order to estimate the parameters Q, G, and H, the correlation coefficient between each month and the corresponding annual streamflow had to be calculated. Equation 3.23 was used to calculate these correlation coefficients between untransformed monthly and annual values:

$$r_{yj,\tau} = \frac{\sum_{\nu=1}^{n} \left(x_{\tau,\nu} - \overline{x}_{\tau}\right)\left(y_{\nu} - \overline{y}\right)}{s_{x,\tau} s_{y}} \tag{3.23}$$

where:

τ = month

n = year

x = raw monthly streamflow value

y = raw annual streamflow value

$\overline{x}$ = mean of monthly streamflow

$\overline{y}$ = mean of annual streamflow

s_x = standard deviation of monthly streamflow

s_y = standard deviation of annual streamflow

However, the correlation coefficients as calculated from equation 3.23 were inappropriate for some of the monthly and corresponding annual series (October, April, July, August, September) since logarithmic transformations were used. Hence, once again, the relationships, as developed for the logarithmic transformation relating the transformed and historical statistics, were utilized. In this particular case, the annual series was to be untransformed, while the several monthly series were to be transformed. Thus, equation 3.17 was used to arrive at the correlation coefficients to be used in estimating the model parameters for the log-transformed monthly records. The resulting correlation coefficients are listed in Appendix G as Table G.3.

f) Disaggregation Model Parameters: The parameters Q, G, and H for Lane's disaggregation model were estimated using equations 3.17 and the statistics shown in Tables G.2, and G.3. The resulting estimates are listed in Appendix G , Table G.4.

g) Model Application: Using the disaggregation model, the monthly data of the 1925-1948 water years for the Big Lost River were generated. However, when filling in the missing monthly flows of 1925-1948, if the actual monthly data existed for this period, the generated values were disregarded, and instead the actual values were used. The filled-in monthly records of each year were summed to form annual records. The formed annual records were compared with the annual flows generated by the annual multivariate AR(1) modeling. The difference between the two annual time series (one was the sum of the monthly flows by the disaggregation modeling, the other was annual flows by the annual multivariate AR(1) modeling) of each year for the 1925-1985 water years was calculated, and the results are shown in Appendix G, Table G.5.

3.3 Conclusion: As described earlier, the annual flows (by the annual multivariate AR(1) modeling) were compared with the sum of the monthly flows (by the monthly multivariate AR(1) modeling) in Table G.6. Again, the annual flows by the annual multivariate AR(1) modeling were compared with the sum of the monthly flows by the disaggregation modeling in Table G.5. From these comparisons, it was seen that the sum of the monthly flows of each year by the annual monthly multivariate AR(1) modeling agreed more closely with the annual flows by the annual multivariate AR(1) modeling. Thus, the results using the annual monthly multivariate AR(1) modeling approach were concluded to be more acceptable than those of the disaggregation model approach, in this particular application. Therefore, the results of the multivariate AR(1) model were selected to represent the complete flow record at Big Lost River station (13.1205.00) for the years 1925 to 1948. The final records are shown in Appendix D, Table D.2

4. Camas Creek (13.1415.00)

The Camas Creek station (13.1415.00) has a partial record from 1925-1944 (for most years in the months of October through March; for three years in April; and for only one year in May). Because development of groundwater for irrigation on a significant scale reportedly began in 1953 (46), the cut-off date between "natural streamflow" and streamflow affected by groundwater withdrawals within the Camas Creek basin was assumed to be the 1953 water year. Therefore, the overlap period between a long-term key station and the subordinate station (13.1415.00) could be as short as only eight years (1945-1952) in the months of December through February (Table B.4)

Several trials were conducted to find a long-term key station that could be used to fill in the data at the subordinate station (13.1415.00). From the trials, it was seen that only two nearby stations have the records of 1925 through 1952. One station was Big Wood Slough (13.1395.10), the other was Goose Creek (13.0825.00). The correlation coefficients of the monthly streamflows were calculated between Camas Creek (13.1415.00) and Big Wood Slough (13.1395.10), and between Camas Creek (13.1415.00) and Goose Creek (13.0825.00). The two comparisons (Table H.1) showed that eight of the twelve monthly correlation coefficients between Camas Creek and Big Wood Slough were higher than the monthly correlation coefficients between Camas Creek and Goose Creek. Therefore, Big Wood Slough station (13.1395.10) was determined to be a better pairing station and was selected as the key station for the Camas Creek station (13.1415.00). As described earlier in this section, the overlap period between the key station (13.1395.10) and the subordinate station (13.1415.00) was very short (only eight years in the months of December through February). Therefore, a simple spatial regression (equation 3.1) was applied. The coefficient of determination (the proportions of variability in Y explained by the relationship) for each month was calculated. The results (Table I.1) showed poor coefficients of determination for the months of January through May.

A polynomial (quadratic) regression approach described below was sought to get a better representation for this data. The coefficients of determination of each month were calculated and compared to those results by the simple regression approach. The results (Table I.1) showed that the polynomial (quadratic) regression method appeared to be better than the linear regression approach for these particular data. The coefficients of determination for the months of January and February were still not good. However, the streamflows of the winter season were small in quantity compared with the other seasons. Therefore, the polynomial (quadratic) regression was chosen to fill the data of the missing monthly record from 1925 through 1944 for the Camas Creek station.

4.1 Model Description: A polynomial (quadratic) regression equation can be written as follows:

$$Y_\tau = \alpha_\tau + \beta 1_\tau X_\tau + \beta 2_\tau X_\tau^2 + \varepsilon_\tau \quad (3.24)$$

where:

τ = month

Y = monthly streamflow value at subordinate station

X = monthly streamflow value at key station

ε = residual series

The parameters estimates (α_τ, $\beta 1_\tau$, $\beta 2_\tau$) were calculated using similar procedures to those described in equations 3.1-3.4, and the results are presented in Appendix I, Table I.2.

4.2 Results: Using the estimates (Table I.2) and the equation 3.24, missing monthly records for the 1925-1944 water years of Camas Creek (13.1415.00) were filled in. These results are provided as Table D.4 in Appendix D. In addition, the simple statistics of monthly flows for each station were provided in Tables D.5 through D.8.

CHAPTER 4

MULTIVARIATE MODEL DEVELOPMENT

1. Introduction to the Previous Modeling Approaches

For several decades, researchers in Idaho have recognized both the importance of the State's groundwater resources, as well as the fact that their use may have a significant effect on surface water within the pumped basins. Ralston (1) studied the groundwater development of the Snake River Plain and the tributary basins and indicated that the groundwater resources of Idaho are a major key to the agricultural future of the State. He also concluded that this particular region has the greatest potential for the continued development of groundwater for irrigation.

However, the pumping of groundwater throughout the Snake River Plain has had a growing influence on the streamflows of the region and has resulted in a number of water management issues and problems. For this reason, numerous groundwater studies have been undertaken in recent years in an attempt to analyze the conjunctive use characteristics of this important region. All prior efforts have used deterministic modeling approaches described below.

1.1 Deterministic Groundwater Models: Traditionally, the approaches to analyze the conjunctive use of surface and groundwater resources have used deterministic modeling of the groundwater aquifer system, in either 2- or 3-dimensions. Many of the research studies, such as those by Hybbert (2), Todd (3), Toth (4), and De Wiest (5), have dealt with the mathematical development and the analytical solution of differential equations which govern groundwater flow. Todd (3) explained finite-difference methods, finite-element methods, and hybrid computer models in terms of a digital computer model. The finite-difference method is a computational procedure based on dividing an aquifer into a grid and analyzing the flows associated within a single zone of the aquifer. The finite-element technique involves solving a differential equation for groundwater flow by means of variational calculus.

A combination of a digital model and a resistance network analog, known as a hybrid computer model, has been developed to reduce the lengthy computer time sometimes required for iterative finite-difference solutions. The digital computer provides the input data, such as sources, sinks, and aquifer properties and boundaries; these are expressed in electric form by a digital-analog converter and connected with a resistance network by means of a distributor. After the analog relaxes the system, the node voltages are fed back to the digital computer through a multiplexer and an analog-digital converter. This approach is most advantageous for solving iteration-intensive problems such as non-steady flows in unconfined aquifers. Because these approaches use approximate numerical solutions of the finite difference equations, it has often been difficult to apply them to complex, real problems. Todd (3) also pointed out gaps that exist between the need for and the actual use of groundwater models in management: 1) Difficulties in the accessibility of existing models to potential users form a serious impediment; documentation including descriptions of models, listings of codes, and user's manuals would help alleviate this problem. 2) There is need for improved communications between water managers and technical personnel responsible for modeling. 3) Because of inadequacies of input data, the reliability of model output is often seriously questioned; hence, more cost-effective means of data collection are required. 4) Improvements in modeling are needed to make computer codes more understandable and easier to use. 5) Further model development is needed for more complicated aspects.

Peaceman and Rachford (6) introduced a method to improve the speed of the computational process and to solve the problems of instability for any size of time step. Their work simplified the application problems and has helped to evolve a family of models which can be used to study multi-layer groundwater systems. Further development work by the USGS, Bredehoeft and Pinder (7), Trescott, et al (8), and Dabiri, et al (9), has led to models which can analyze the effects of groundwater pumping and recharge on subsurface storage, watertable drawdown, and streamflow.

Bredehoeft and Pinder (7) asserted that when the hydrologic system is represented by aquifers in which flow is assumed horizontal, and confining layers in which flow is assumed vertical, the problem can be reduced to solving two-dimensional equations for each aquifer, the aquifers being coupled through leakage. They used an iterative scheme to simultaneously solve the finite difference equations describing the response of confined and unconfined acquifers with or without storage in the confining layer.

Trescott, et al (8) contended that the digital model is a versatile tool in groundwater development and management because it allows the immediate and long-term effects of proposed well fields to be investigated prior to installation. He indicated that when non-homogeneity of the porous media and complex aquifer geometry make pumping-test analysis difficult, if not impossible, a digital model can be used to evaluate boundary effects. He concluded that it is important in making digital models of such aquifers to have good geological control; otherwise excessive time can be consumed adjusting parameters in the model in an effort to duplicate aquifer response to pumping stress.

In Idaho, De Sonneville (10) developed a digital groundwater model to undertake a groundwater study in the upper Snake River Basin, and later extended the model (10). The mathematical model (10) developed is a finite difference digital model, like models of Bredehoeft and Pinder (7), and calculates hydraulic head values on a gridpoint basis. Newton (11) updated the model which was also applied to the Silver Creek aquifer in Blaine County (12), the Henry's Fork area (13), the Boise Valley aquifer (14), and to the Mud Lake area (15). Lindgren (14) had two main objectives in modeling the Boise groundwater system. The first was to develop the capability to generate reach gains and losses on the Boise and Snake Rivers resulting from the modification of the present irrigation management scheme. The second was to describe the changes in the groundwater surface caused by changing the system. During the years of use, various calibration and management versions of the model have evolved. However, because of the complexity of these models, the cost of model application is expensive and the data requirements are significant.

1.2 Other Deterministic Studies of Conjunctive Use: Numerous prior studies (16, 17, 18, 19, 20, 21, 22, 23, 24) in the United States have offered other methods of analysis of the conjunctive use of surface water and groundwater. Most of these studies employed a simple hydrologic model of the stream-alluvial aquifer system, developed for maximizing the beneficial uses of the waters of a state. Examples of such coordinated basin management models include studies for basins in California, Colorado, Idaho, Maryland, and New York. Beaver, and Frankel (16) used system analysis technology for the groundwater resource management in southern California's San Bernardino valley. In the simulation of the Valley's groundwater basins, the mathematical model has been designed to develop a history of water table or piezometric head movements with time.

Bittinger (20) explains that the highest beneficial use of total water resources can only be obtained through a combined or integrated use of both surface and groundwater. He gave a simple hypothetical stream-aquifer situation to illustrate the influence of groundwater pumping upon surface flows and water available for diversion. He also suggested that legal and economic factors must be considered in designing the physical situation.

Morel-Seytoux (21) developed a specific hydrologic model of a stream-alluvial aquifer system for the purpose of designing rules and regulations which maximize the beneficial uses of the waters of a state within the law. The model is particularly applicable when decisions on pumping rates are to be reviewed on a frequent basis.

Taylor (22) explains that the unrestricted development of groundwater can reduce streamflows and hence jeopardize the rights to the flow of surface water where aquifers are intimately associated with streams. He has developed a simulation model to aid in the solution of such problems. This hydrologic model represents the physical response of the stream-aquifer system to changes in river flows, diversions, and pumping. It treats streamflow as a stochastic input and an economic model that represents the response of irrigation water users to variations in water supply and cost.

Simple relationships between the pumping of a well and the resulting depletion of a nearby stream have been derived by several investigators (25, 26, 27, 28, 29, 30). They have shown these relationships in the form of equations and charts. However, such charts are useful as computational tools only in the range of comparatively large effects; and rather formidable equations must be solved to evaluate small effects.

Conover (26) studied pumping effects of the groundwater in Rincon and Mesilla valley in New Mexico. He concluded that in order to have reliable data for a future revaluation of the effects of pumping, if such becomes desirable, the following records should be kept: information on the irrigation wells such as, location, performance, and pumpage; measurements of water level in the irrigation wells annually and in the auger wells seasonally; and additional measurements of drain flow.

Theis (29) explained that pumping water from a well that taps an aquifer which is hydraulically connected with a stream or drain reduces the flow of surface water either by reducing the flow of groundwater to the stream or drain or by causing the surface water to infiltrate the aquifer and percolate toward the well. He provided a chart for determination of the percentage of pumped water being diverted from a stream or drain. He insisted that if the hydraulic constants of the aquifer are known, then the theoretical percentage of surface water in the discharge of the well (at a given distance from the stream or drain and at a given time since pumping began) can be determined readily through use of the chart.

Jenkins (31) provided tools that simplify the seemingly intricate computations and gave examples of their use. By using his curves and tables, the depletion in flow of a nearby stream caused by pumping a well can be calculated readily when field conditions approach certain assumed conditions. Computations can be made of the rate of stream depletion at any time during the pumping period or the following nonpumping period, the volume of water induced from the stream during any period, pumping or nonpumping, and the effects, both in rate and volume of stream depletion, of any selected pattern of intermittent pumping. He provided sample computations to illustrate the use of the curves and tables.

However, the application of these deterministic models is an expensive and time-consuming process, and their accuracy is often dependent upon extensive input data requirements. Moreover, the extensive input data are not available for most research study areas.

1.3 Stochastic Models: A detailed literature review has not disclosed any prior studies in Idaho (or in other areas within the U.S) that have used stochastic methods to investigate the conjunctive use of surface and groundwater. Although such methods have been frequently used to study the long term behavior of streamflow or groundwater storage, there has been no attempt to undertake the type of research performed for this project, where a modeled natural flow regime is compared to an observed altered flow regime.

2. Multivariate Models and Model Selection

Since the early 1960's, extensive research efforts have been concentrated on developing methods to analyze the stochastic characteristics of hydrologic series and to devise generating schemes for univariate hydrologic series. Periodic multivariate models are necessary to generate multiple periodic series at several sites. For instance, a water resource system of several reservoirs may require the generation of monthly streamflows at several sites in order to simulate the operation of such a system. If monthly streamflow data are available at the site of interest, a periodic multivariate model can be used to model and generate monthly streamflows at those sites (40).

The multivariate modeling of surface streamflow, using subordinate station data to predict or extend the streamflow record at key station, is well documented and has been extensively applied. In 1964, Fiering (32) proposed multivariate analysis for the simultaneous generation of synthetic flow sequences at a key station X and a subordinate station Y to preserve the lag-one serial and lag-zero cross correlation coefficient of the two stations. However, subsequent examination of this model by others (33,34) showed that these correlation coefficients were not preserved unless some constraint conditions were met. Lawrance (34) presented a modification of the Fiering model that preserves the lag-one serial and lag-zero cross correlation coefficients with much less stringent constraints. In 1973, Yevjevich (35) presented an improved multisite model which can reduce time dependence, skew coefficient, and variance of the model residuals, while preserving all of the individual station statistics.

The general model structure of an AR(1) Model with monthly parameters is given by:

$$Z_{\nu,\tau} = A_{1,\tau} Z_{\nu,\tau-1} + B_{\tau}\, \varepsilon_{\nu,\tau} \qquad (4.1)$$

where $A_{1,\tau}$ is an nxn monthly coefficient matrix associated with the time interval τ, $Z_{\nu,\tau-1}$ is an nx1 vector of standardized monthly values, B_{τ} is an nxn monthly matrix for time interval τ, and $\varepsilon_{\nu,\tau}$ is an nx1 vector of time independent, normally distributed random variables. The sequences, $Z_{\nu,\tau}$ and $\varepsilon_{\nu,\tau}$ have expected values equal to zero, and variances equal to one.

This model has the property to preserve the historical means, standard deviations, the lag-zero and the lag-one cross correlation and the lag-one autocorrelation. A recent study (36) has shown that the Yevjevich model was clearly superior to the other earlier models in properly modeling the flows on several Idaho streams. For this reason, the multisite AR(1) model was applied to this study.

For the record period of 1925 to the cut-off date of 1952, the multivariate AR(1) model can be developed to relate the Camas Creek monthly flows to the flows on the other three streams. When the monthly flows at stations of Big Wood Slough, Big Lost River, Goose Creek, and Camas Creek were used, the above four sites were numbered as 1, 2, 3, and 4, respectively.

Using the representation of equation 4.1, the generating AR(1) model for one key station and three subordinate stations can be written as:

$$Z_{\nu,\tau}^{(1)} = a^{11} Z_{\nu,\tau-1}^{(1)} + a^{12} Z_{\nu,\tau-1}^{(2)} + a^{13} Z_{\nu,\tau-1}^{(3)} + a^{14} Z_{\nu,\tau-1}^{(4)} + b^{11}\varepsilon_{\nu,\tau}^{(1)} + b^{12}\varepsilon_{\nu,\tau}^{(2)} + b^{13}\varepsilon_{\nu,\tau}^{(3)} + b^{14}\varepsilon_{\nu,\tau}^{(4)}$$

$$Z_{\nu,\tau}^{(2)} = a^{21} Z_{\nu,\tau-1}^{(1)} + a^{22} Z_{\nu,\tau-1}^{(2)} + a^{23} Z_{\nu,\tau-1}^{(3)} + a^{24} Z_{\nu,\tau-1}^{(4)} + b^{21}\varepsilon_{\nu,\tau}^{(1)} + b^{22}\varepsilon_{\nu,\tau}^{(2)} + b^{23}\varepsilon_{\nu,\tau}^{(3)} + b^{24}\varepsilon_{\nu,\tau}^{(4)}$$

$$Z_{\nu,\tau}^{(3)} = a^{31} Z_{\nu,\tau-1}^{(1)} + a^{32} Z_{\nu,\tau-1}^{(2)} + a^{33} Z_{\nu,\tau-1}^{(3)} + a^{34} Z_{\nu,\tau-1}^{(4)} + b^{31}\varepsilon_{\nu,\tau}^{(1)} + b^{32}\varepsilon_{\nu,\tau}^{(2)} + b^{33}\varepsilon_{\nu,\tau}^{(3)} + b^{34}\varepsilon_{\nu,\tau}^{(4)}$$

$$Z_{\nu,\tau}^{(4)} = a^{41} Z_{\nu,\tau-1}^{(1)} + a^{42} Z_{\nu,\tau-1}^{(2)} + a^{43} Z_{\nu,\tau-1}^{(3)} + a^{44} Z_{\nu,\tau-1}^{(4)} + b^{41}\varepsilon_{\nu,\tau}^{(1)} + b^{42}\varepsilon_{\nu,\tau}^{(2)} + b^{43}\varepsilon_{\nu,\tau}^{(3)} + b^{44}\varepsilon_{\nu,\tau}^{(4)} \quad (4.2)$$

where:

$Z_{\nu,\tau}^{(i)}$ = standardized monthly flows for station (i = 1, 2, 3, 4)

a's and b's = the elements of the estimated matrix parameters A1 and B

$\varepsilon_{\nu,\tau}^{(4)}$ = independent and identically distributed normal (0,1) deviate for i = 1,2,3,4

ν = 1,2, ..., N
(N is the number of years of records)

τ = 1,2, ..., w
(w is the number of time periods within the year)

Because it is assumed that B is a lower triangular matrix, equation 4.2 can be changed as follows to generate monthly flows of the one key station (Camas Creek), using monthly flows of the three subordinate stations (Big Wood Slough, Big Lost River, Goose Creek).

$$\varepsilon_{\nu,\tau}^{(1)} = 1/b^{11} \left(Z_{\nu,\tau}^{(1)} - a^{11} Z_{\nu,\tau-1}^{(1)} - a^{12} Z_{\nu,\tau-1}^{(2)} - a^{13} Z_{\nu,\tau-1}^{(3)} - a^{14} Z_{\nu,\tau-1}^{(4)}\right)$$

$$\varepsilon_{\nu,\tau}^{(2)} = 1/b^{22} \left(Z_{\nu,\tau}^{(2)} - a^{21} Z_{\nu,\tau-1}^{(1)} - a^{22} Z_{\nu,\tau-1}^{(2)} - a^{23} Z_{\nu,\tau-1}^{(3)} - a^{24} Z_{\nu,\tau-1}^{(4)} - b^{21}\varepsilon_{\nu,\tau}^{(1)}\right)$$

$$\varepsilon_{\nu,\tau}^{(3)} = 1/b^{33} \left(Z_{\nu,\tau}^{(3)} - a^{31} Z_{\nu,\tau-1}^{(1)} - a^{32} Z_{\nu,\tau-1}^{(2)} - a^{33} Z_{\nu,\tau-1}^{(3)} - a^{34} Z_{\nu,\tau-1}^{(4)} - b^{31}\varepsilon_{\nu,\tau}^{(1)} - b^{32}\varepsilon_{\nu,\tau}^{(2)}\right)$$

$$\varepsilon_{\nu,\tau}^{(4)} = \text{random number (normal deviate)} \quad (4.3)$$

$$Z_{\nu,\tau}^{(4)} = a^{41} Z_{\nu,\tau-1}^{(1)} + a^{42} Z_{\nu,\tau-1}^{(2)} + a^{43} Z_{\nu,\tau-1}^{(3)} + a^{44} Z_{\nu,\tau-1}^{(4)} + b^{41}\varepsilon_{\nu,\tau}^{(1)} + b^{42}\varepsilon_{\nu,\tau}^{(2)} + b^{43}\varepsilon_{\nu,\tau}^{(3)} + b^{44}\varepsilon_{\nu,\tau}^{(4)} \quad (4.4)$$

To generate standardized monthly values of the key station $(Z_{v,\tau}^{(4)})$ using the standardized monthly values of the three subordinate stations, the following two steps are necessary: the first step requires the calculation of four standardized normal random numbers , $\varepsilon_{v,\tau}^{(1)}$, $\varepsilon_{v,\tau}^{(2)}$, $\varepsilon_{v,\tau}^{(3)}$, and $\varepsilon_{v,\tau}^{(4)}$ using equation 4.3; and the second step is to generate a $Z_{v,\tau}^{(4)}$ value, using the above calculated standardized normal random numbers and equation

3. Preliminary Analysis

The main purposes of this analysis were to check the normality of the original monthly time series, and to make appropriate transformations to normal, if necessary. The normality of the raw monthly series and lognormal transformed monthly series for the four stations was checked by determining if the coefficient of skewness of each series did not differ from zero. Equation 3.18 was used for the bounds for a coefficient of skew equal to zero at the 5 % significance level. The computed skew coefficients for the raw monthly series for the four stations are listed in Appendix J , Table J.1. Although some monthly series of Goose Creek used for modeling (January, February, July, August, September) were not valid for the assumption of normality, the monthly flows of the other three stations (including the key station) were valid for the normality assumption either in a raw monthly series or in a log normal transformed monthly series for those months. Therefore, it was decided to relax the normality assumption for those months of Goose Creek. The series corresponding to the skew coefficients in Table J.1 of Appendix J marked with an " * " were the series used for modeling. Based on each normalized series (four stations) from the previous step, the monthly mean, monthly standard deviation, and the monthly correlation coefficients (lag-zero, and lag-one) for each series were computed. The resulting statistics are listed in Appendix K , Tables K.1 through K.12.

4. Estimation of Parameters

The standardized variate $Z_{\nu,\tau}^{(i)}$ is:

$$Z_{\nu,\tau}^{(i)} = \frac{Y_{\nu,\tau}^{(i)} - \overline{X}_{\nu,\tau}^{(i)}}{S_{\nu,\tau}^{(i)}} \quad i = 1,2,3,4 \tag{4.5}$$

where $Y_{\nu,\tau}^{(i)}$ is normalized value of the monthly stream flows, and $X_{\nu,\tau}^{(i)}$ and $S_{\nu,\tau}^{(i)}$ are the estimated values of the mean and standard deviation of the normalized series.

With the AR(1) model for four stations, the monthly matrix parameter estimates for the model of equation 4.1 can be obtained from (49):

$$A_{1,\tau} = M_{1,\tau}\ M^{-1}{}_{0,t-1} \tag{4.6}$$

and

$$B_\tau B_\tau^T = M_{0,\tau} - M_{1,\tau}\ M^{-1}{}_{0,\tau-1}\ M^T{}_{1,\tau} \tag{4.7}$$

where $M_{0,\tau}$, $M_{0,\tau-1}$, and $M_{1,\tau}$ are the monthly matrix correlations given by:

$$M = \begin{bmatrix} r_{\kappa,\tau}^{11}, & r_{\kappa,\tau}^{12}, & r_{\kappa,\tau}^{13}, & r_{\kappa,\tau}^{14} \\ r_{\kappa,\tau}^{21}, & r_{\kappa,\tau}^{22}, & r_{\kappa,\tau}^{23}, & r_{\kappa,\tau}^{24} \\ r_{\kappa,\tau}^{31}, & r_{\kappa,\tau}^{32}, & r_{\kappa,\tau}^{33}, & r_{\kappa,\tau}^{34} \\ r_{\kappa,\tau}^{41}, & r_{\kappa,\tau}^{42}, & r_{\kappa,\tau}^{43}, & r_{\kappa,\tau}^{44} \end{bmatrix} \tag{4.8}$$

for k= 0,1 and τ = 1, ..., 12. The monthly correlation coefficients $r_{\kappa,\tau}^{ij}$ are obtained by correlating $Z_{\nu,\tau}^{(i)}$ with $Z_{\nu,\tau-\kappa}^{(i)}$. The elements of the matrix B_τ

can be obtained by use of equations 3.12 through 3.14. The calculated matrices $M_{0,\tau}$ and $M_{1,\tau}$ are listed in Appendix K , Tables K.1 through K.12.

5. Data Generation

The multivariate AR(1) model for the synthetic generation of the monthly series for the key station (Camas Creek) can be obtained by substituting the estimated parameters into their corresponding model equations. Thus, the generation of the monthly series for the key station $X_{v,\tau}^{(4)}$ can be made by:

$$X_{v,\tau}^{(4)} = \overline{X}_{v,\tau} + S_{x,\tau}^{(4)} Z_{x,\tau}^{(4)} \text{, for raw monthly series} \tag{4.9}$$

and

$$X_{v,\tau}^{(4)} = \exp\left(\overline{Y}_{v,\tau}^{(4)} + S_{y,\tau}^{(4)} Z_{v,\tau}^{(4)}\right) \text{, for transformed monthly series} \tag{4.10}$$

where $\overline{X}_{v,\tau}^{(4)}$ and $S_{x,\tau}$ are the estimates of the monthly mean and monthly standard deviation for the raw monthly series, and $\overline{Y}_{v,\tau}$ and $S_{y,\tau}$ are the estimate of the monthly mean and monthly standard deviation for the log-transformed monthly series. $Z_{v,\tau}^{(4)}$ is the standardized, normalized monthly flow generated by equation 4.4. The following relationships (50) were used to relate the characteristics of the untransformed variate $X_{v,\tau}$ and the transformed variate $Y_{v,\tau}$:

$$\overline{Y}_{v,\tau} = 1/2 \log\left[\frac{\overline{X}_{v,\tau}^{2}}{\left(C_{v,\tau}^{2} + 1\right)}\right] \tag{4.11}$$

$$S_{y,\tau}^2 = \log\left(C_{v,\tau}^2 + 1\right) \tag{4.12}$$

where C_v is the coefficient of the variation of the raw data ($C_{v,\tau} = S_{x,\tau}/\overline{X}_{v,\tau}$).

These results are provided in Table L.1 and L.2 in Appendix L. For the period of natural flow (1925-1952) on the four streams, the historical data from the subordinate stations were used to generate monthly flows for Camas Creek. The historical monthly flows and the generated monthly flows for Camas Creek for the period of natural flow (1925-1952) were plotted in Fig.L.1 through Fig.L.12. In addition, the historical annual flows and the generated annual flows (monthly sums) at Camas Creek were plotted in Fig.L.13. Although the model appeared to simulate overall historical time series reasonably well, its performance varied by month and season. The poorest agreement between modeled and observed flows occurs in the peak spring runoff months and is probably attributable to variations in snowpack among the four basins used in the model development. As typical results of monthly flows and the results of annual flows, copies of Fig.L.8 and Fig.L.13 are included here as Fig.4.1 and Fig.4.2. Statistical comparisons (mean, variance, skew) were performed between the historical and generated monthly series. Hypothesis tests were used to compare the statistics of the two series (historical vs. generated) for each month and annual flows (39,41). A paired mean difference t-statistic (Table 4.1) was considered in order to compare the statistics of the two series. The variability of the two series were considered to understand the results by the paired mean difference testing. Therefore, equality of the variances between two series was first tested by using an F-statistic (Table 4.2). Then the means of the two series were tested using the paired difference t-statistic. The results of these tests are presented in Table 4.3

Table 4.1

Hypothesis Tests using F- and Paired Difference t-statistics

F-statistic

Null Hypothesis: $\sigma_h^2 = \sigma_g^2$

Alternative Hypothesis: $\sigma_h^2 \neq \sigma_g^2$

Test Statistics: F = (larger of s_h^2, s_g^2) / (smaller of s_h^2, s_g^2)

Degrees of Freedom: n-1

(n = sample size of s_h^2 and s_g^2)

t-statistics

Null Hypothesis: $\mu_h - \mu_g = \mu_d = D_0 = 0$

Alternative Hypothesis: $D_0 \neq 0$

Test Statistic:

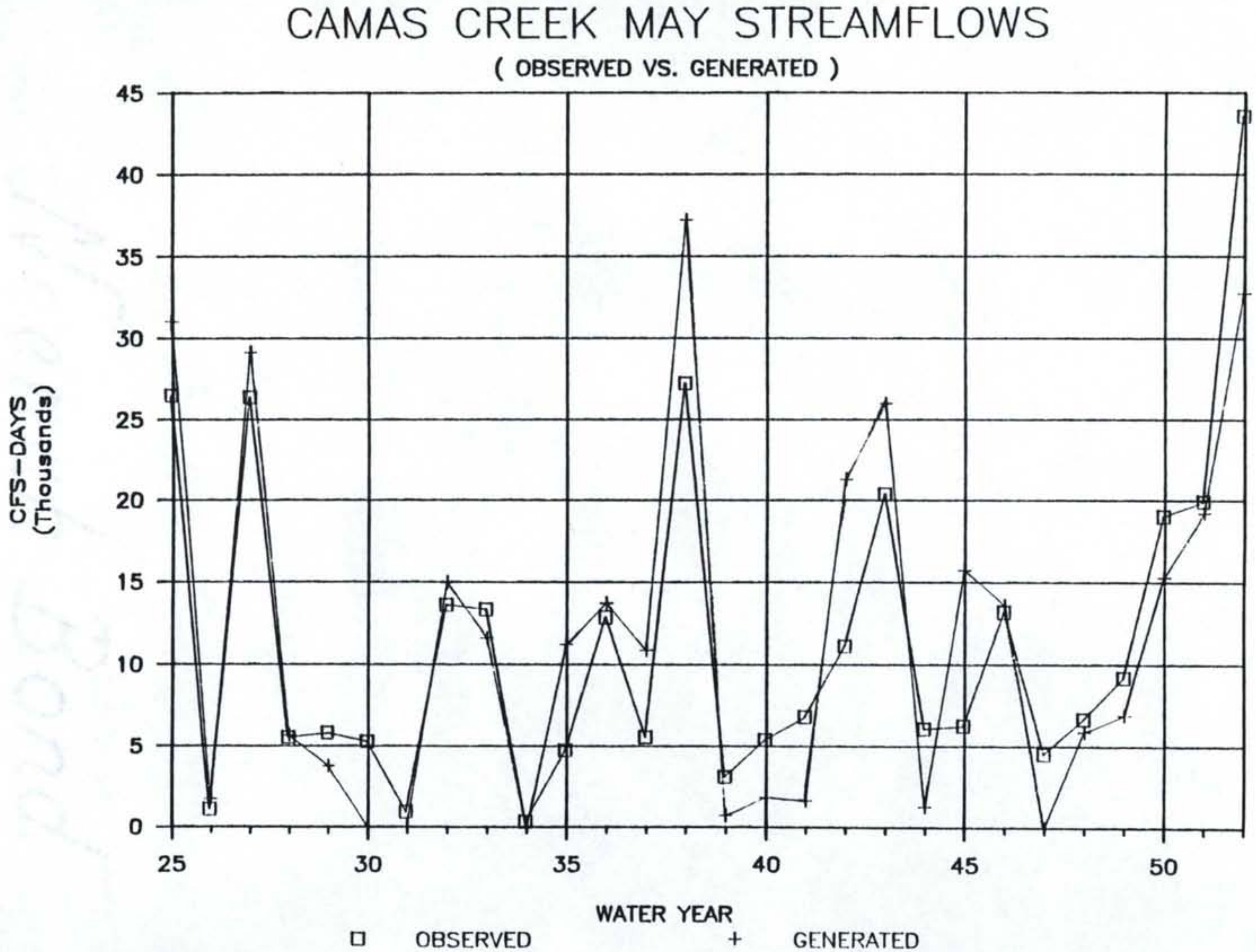
$$t = \frac{\bar{d} - D_0}{s_d / \sqrt{n}}$$

Degrees of Freedom: n-1

where the subscripts h and g represent the two series of each length, n. The Greek letters represent the population statistics while the lowercase letters represent the sample estimates of these statistics. d and s_d are the sample mean and standard deviation of the n differences.

From Table 4.2, it was seen that at the 5 % level of significance, the null hypotheses of equality of variance between the two monthly series were not rejected, except for September flows. Likewise, from Table 4.3 no significant differences between the means for the two monthly series for all months were found. From Fig.L.12, it was seen that the difference of the variance in the September flows was caused by the generated outlier of the 1940 record. Coefficients of skew (Table L.3) for the historical monthly streamflows and the generated monthly flows were compared on a monthly basis. The comparison showed that the skew coefficients of all but two months (February, September) were similar to each other. It was concluded that the differences of the skew coefficients of the two months were caused by the relaxed normality assumption for those months of Goose Creek station (section 3 of this chapter). Also, the correlation coefficients between historical monthly flows and generated monthly flows were compared in Appendix L, Table L.4. Generally, the correlation coefficient between historical monthly flows and generated monthly flows for each month preserved the correlation coefficient between the key station and the three other subordinate stations (Tables K.1 through K.12). From these results, it was concluded that the modeled generated flows were statistically similar to the historical flows.

Fig. 4.1



CAMAS CREEK MAY STREAMFLOWS
(OBSERVED VS. GENERATED)
CFS-DAYS (Thousands)
WATER YEAR
OBSERVED
GENERATED

Fig. 4.2

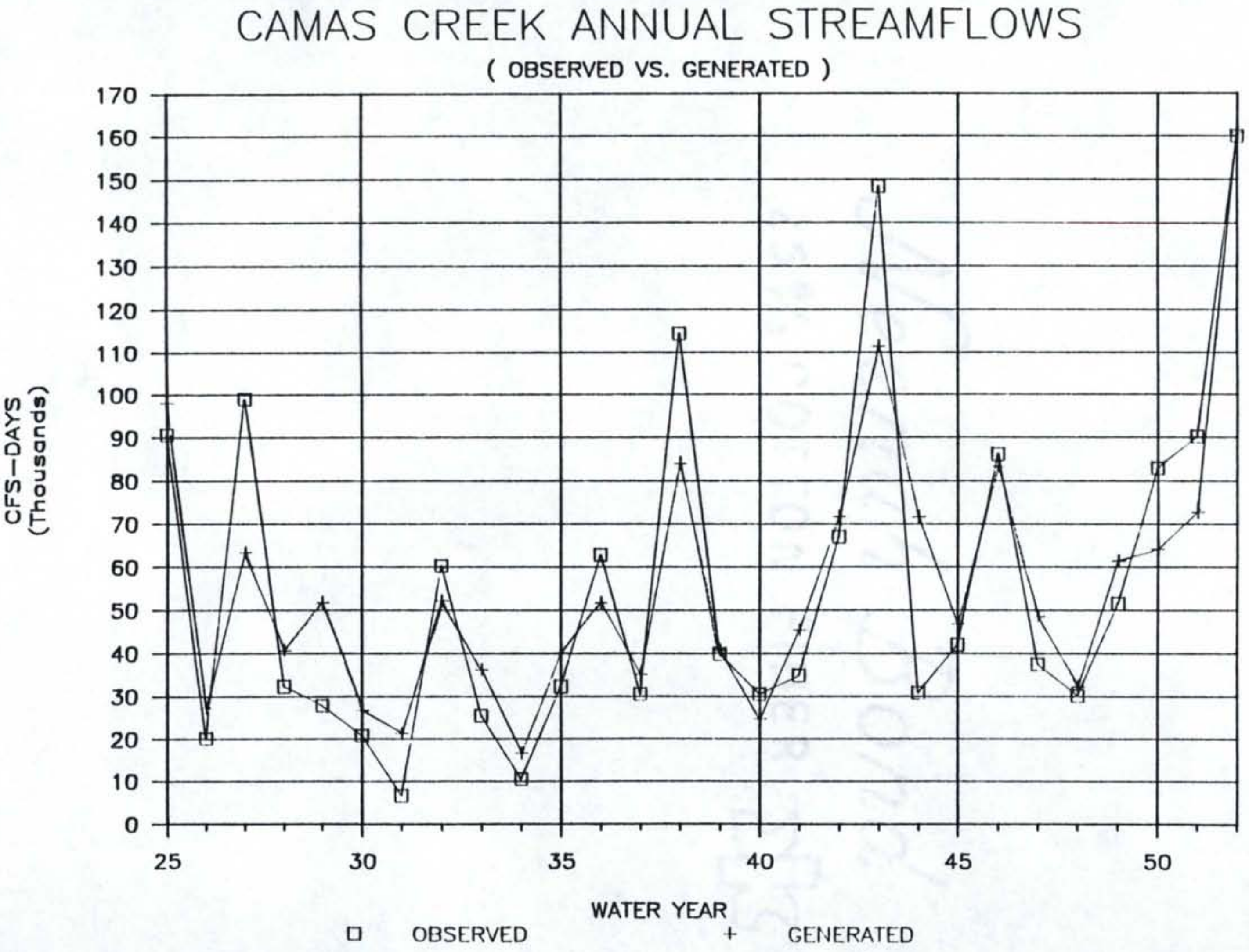

CAMAS CREEK ANNUAL STREAMFLOWS
(OBSERVED VS. GENERATED)
CFS—DAYS
(Thousands)
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
25
30
35
40
45
50
WATER YEAR
OBSERVED
GENERATED

Table 4.2

Hypothesis Test for Equality of Variances
between Two Monthly Series
(for 1925 -1952 Water Years)

Month	Years	Std (h) (Cfs-days)	Std (g) (Cfs-days)	Sample F	5 % F	Unequal/Equal
Oct	28	119	97	1.48	2.16	equal
Nov	28	267	224	1.42	2.16	equal
Dec	28	438	375	1.36	2.16	equal
Jan	28	218	253	1.34	2.16	equal
Feb	28	1048	809	1.68	2.16	equal
Mar	28	3950	3485	1.28	2.16	equal
Apr	28	28690	22098	1.69	2.16	equal
May	28	10069	11235	1.24	2.16	equal
Jun	28	2891	3564	1.52	2.16	equal
Jul	28	696	779	1.25	2.16	equal
Aug	28	113	97	1.35	2.16	equal
Sep	28	69	202	8.41	2.16	unequal
Ann	28	39693	31124	1.63	2.16	equal

* " Std (h) " = Standard Deviation of the Historic Monthly Streamflows

* " Std (g) " = Standard Deviation of the Generated Monthly Streamflows

Table 4.3

Hypothesis Test of Paired Mean Difference
between Two Monthly Series
(for 1925 -1952 Water Years, Streamflow in cfs-days)

Month	Years	Mean	Std Error	Sample t	5 % t	Unequal/Equal
Oct	28	-2.68	13.78	-0.19	-2.05	equal
Nov	28	10.30	31.15	0.33	2.05	equal
Dec	28	11.79	83.72	-0.14	-2.05	equal
Jan	28	15.89	30.04	0.53	2.05	equal
Feb	28	-197.55	211.98	-0.93	-2.05	equal
Mar	28	-419.53	417.67	-1.00	-2.05	equal
Apr	28	1070.62	3829.38	0.28	2.05	equal
May	28	-285.11	952.64	-0.30	-2.05	equal
Jun	28	-638.32	361.22	-1.77	-2.05	equal
Jul	28	-19.84	09.35	-0.18	-2.05	equal
Aug	28	2.53	16.07	0.16	2.05	equal
Sep	28	-33.45	32.93	-1.02	-2.05	equal
Ann	28	-508.95	3190.34	-0.16	-2.05	equal

CHAPTER 5

MODEL APPLICATION

1. Introduction

The model described in the previous chapter was applied to the time period 1953-1985, subsequent to the reported date of initiation of significant groundwater withdrawals. The monthly flow records at the subordinate stations were used to generate "synthetic-natural" monthly flow series on Camas Creek through the 1985 water year.

2. Adjustment of the Simple Statistics for the Wet Period

The comparisons of monthly means and standard deviations between the periods 1925-1952 and 1953-1985 for three subordinate stations showed that the period 1925-1952 was drier than the period 1953-1985 (Tables M.1 through M.3). The F-statistic (for the variance, s_d^2, of the historical time series for the period of 1925-1952 and the variance, s_w^2, of the historical time series for the period of 1953-1985) was tested for the null hypothesis, $H_0 : \sigma_d^2 = \sigma_w^2$, and the alternative hypothesis, $H_a : \sigma_d^2 < \sigma_w^2$, on the two series of each subordinate station. Depending on the results of these tests of the variances, appropriate t-tests were then run on the monthly means. Table 5.1 summarizes the hypothesis tests and the F- and t- statistics used in conducting them.

Table 5.1

Hypothesis Tests using F- and t-statistics

F-statistic

Null Hypothesis: $\sigma_d^2 = \sigma_w^2$

Alternative Hypothesis: $\sigma_d^2 < \sigma_w^2$

Test Statistics: $F = (s_w^2) / (s_d^2)$

Degrees of Freedom: d-1, w-1 (d = sample size of s_d^2)
(w = sample size of s_w^2)

t-statistics

Null Hypothesis: $\mu_d = \mu_w$

Alternative Hypothesis: $\mu_d < \mu_w$

If $\sigma_d^2 = \sigma_w^2$ as determined by F-statistic, then

Test Statistic:

$$t = \frac{\overline{X}_d - \overline{X}_w}{\left(Sp^2(1/d + 1/w)\right)^{1/2}}, \qquad Sp^2 = \frac{(d-1)s_d^2 + (w-1)s_w^2}{d + w - 2}$$

Degrees of Freedom: d + w - 2

If $s_d^2 \neq s_w^2$ as determined by F-statistic, then

Test Statistic:

$$t = \frac{\overline{X}_d - \overline{X}_w}{\left(s_d^2/d + s_w^2/w\right)^{1/2}}$$

Degrees of Freedom :

$$\frac{\left(s_d^2/d + s_w^2/w\right)^2}{\frac{\left(s_d^2/d\right)^2}{d - 1} + \frac{\left(s_w^2/w\right)^2}{w - 1}}$$

where the subscripts d and w represents two series of lengths d and w, respectively. The Greek letters represent the population statistics while the lowercase letters represent the sample estimates of these statistics.

The results of the variance tests are presented in Tables 5.2, 5.4, and 5.6. From these tables, it is seen that although the variances between the two monthly series for Big Wood Slough were not statistically different for most months, the variances between the two monthly series for the other two subordinate stations were statistically different for most months at the 5 % significance level. The t-statistic (for the mean, μ_d, of the historical time series for the period of 1925-1952 and the mean, μ_w, of the historical time series for the period of 1953-1985) was tested as the null hypothesis, $H_0 : \mu_d - \mu_w = 0$, and the alternative hypothesis, $H_a : \mu_d - \mu_w < 0$, on the two series of each subordinate station (Table 5.1). The results (Tables 5.3, 5.5, and 5.7) show that the means between the two monthly series for the three subordinate stations were statistically different for most months at the 5 % significance level. Therefore, it was concluded that an adjustment of the simple statistics (mean, standard deviation) of the dry period (1925-1953) on Camas Creek was necessary to generate a synthetic-natural monthly flow series for the wet period(1953-1985).

The ratios of the mean and standard deviation for each month of both periods for the three subordinate stations were calculated (Tables M.1 through M.3). To know the proportion of variability in the "key" station contributed by each subordinate station, coefficients of determination between monthly flows of Camas Creek and each subordinate station were also calculated by application of the simple spatial regression model. Weighted average ratios of the mean and standard deviation for the wet period on Camas Creek were obtained by weighting three coefficients of determination to the ratios of the mean and standard deviation of monthly data of both periods for the three subordinate stations. Finally, using the calculated weighted ratios of the mean and standard deviation for the wet period on Camas Creek and the mean and standard deviation for the dry period on Camas Creek, the "natural" monthly mean and standard deviation (necessary model parameters) for the wet period on Camas Creek were estimated.

As an example, the estimating procedure of the "natural" monthly mean of October flows for the wet period on Camas Creek was provided in Appendix M, Table M.4. The results of the estimated monthly statistics for the wet period of Camas Creek, using weighted average ratios of the mean and standard deviation between two periods, are presented in Appendix M, Table M.5.

3. Model Application

The model was applied to generate a synthetic-natural monthly flow series on Camas Creek for the period of 1953-1985. The historical monthly flows (assumed to be affected by pumping) and the synthetic-natural monthly flows for Camas Creek for the period of 1953-1985 were presented in Appendix N, Tables N.1 through N.12, and were plotted in Appendix N, Fig.N.1 through Fig.N.12. The historical annual flows and the synthetic-natural annual flows for the same period are presented in Appendix N, Table N.13 and are plotted in Appendix N, Fig.N.13. Fig.N.13 is included here in Fig.5.1.

Table 5.2

Hypothesis Test for Equality of Variances
between Dry and Wet Periods Streamflows
for Big Wood Slough (13.1395.10)

Null Hypothesis: $\sigma_d^2 = \sigma_w^2$

Alternative Hypothesis: $\sigma_d^2 < \sigma_w^2$

Month	Std (d) (Cfs-days)	Std (w) (Cfs-days)	Sample F	5 % F	Null Hypothesis
Oct	1838	1900	1.07	1.85	accept
Nov	1392	1581	1.29	1.85	accept
Dec	999	1165	1.36	1.85	accept
Jan	877	1039	1.40	1.85	accept
Feb	696	807	1.34	1.85	accept
Mar	1518	1492	0.97	1.85	accept
Apr	8616	7940	0.85	1.85	accept
May	18018	22185	1.52	1.85	accept
Jun	19540	24252	1.54	1.85	accept
Jul	10900	13109	1.45	1.85	accept
Aug	3085	4202	1.85	1.85	accept
Sep	1842	2583	1.97	1.85	reject

* " Std (d) " = Standard Deviation of the Historical Monthly Streamflows for 1925-1952 Water Years

* " Std (w) " = Standard Deviation of the Historical Monthly Streamflows for 1953-1985 Water Years

* Sample F = $Std^2(w)/Std^2(d)$

Table 5.3

Hypothesis Test for Equality of Means
between Dry and Wet Periods Streamflows
for Big Wood Slough (13.1395.10)

Null Hypothesis: $\mu_d = \mu_w$

Alternative Hypothesis: $\mu_d < \mu_w$

Month	Mean (d) (Cfs-days)	Mean (w) (Cfs-days)	Sample t	5 % t	Null Hypothesis
Oct	5432	7217	-3.71	-1.67	reject
Nov	5033	6319	-3.34	-1.67	reject
Dec	4507	5575	-3.80	-1.67	reject
Jan	4211	5400	-4.77	-1.67	reject
Feb	3845	4749	-4.63	-1.67	reject
Mar	5205	6011	-2.09	-1.67	reject
Apr	16875	15752	0.53	-1.67	accept
May	38269	43272	-0.96	-1.67	accept
Jun	37074	50464	-2.35	-1.67	reject
Jul	17112	23550	-2.06	-1.67	reject
Aug	6797	9706	-3.03	-1.67	reject
Sep	5209	7387	-3.83	-1.67	reject

* " Mean (d) " = Mean of the Historical Monthly Streamflows for 1925-1952 Water Years

* " Mean (w) " = Mean of the Historical Monthly Streamflows for 1953-1985 Water Years

Table 5.4

Hypothesis Test for Equality of Variances
between Dry and Wet Periods Streamflows
for Big Lost River (13.1205.00)

Null Hypothesis: $\sigma_d^2 = \sigma_w^2$
Alternative Hypothesis: $\sigma_d^2 < \sigma_w^2$

Month	Std (d) (Cfs-days)	Std (w) (Cfs-days)	Sample F	5 % F	Null Hypothesis
Oct	1273	1237	0.94	1.85	accept
Nov	591	1595	7.28	1.85	reject
Dec	441	1172	7.07	1.85	reject
Jan	385	1033	7.17	1.85	reject
Feb	302	810	7.16	1.85	reject
Mar	393	789	4.02	1.85	reject
Apr	3318	2744	0.68	1.85	accept
May	8658	11827	1.87	1.85	reject
Jun	13606	15206	1.25	1.85	accept
Jul	8815	11508	1.70	1.85	accept
Aug	2508	3583	2.04	1.85	reject
Sep	1137	2164	3.62	1.85	reject

* " Std (d) " = Standard Deviation of the Historical Monthly Streamflows for 1925-1952 Water Years

* " Std (w) " = Standard Deviation of the Historical Monthly Streamflows for 1953-1985 Water Years

* Sample F = $Std^2 (w)/Std^2 (d)$

Table 5.5

Hypothesis Test for Equality of Means
between Dry and Wet Periods Streamflows
for Big Lost River (13.1205.00)

Null Hypothesis: $\mu_d = \mu_w$
Alternative Hypothesis: $\mu_d < \mu_w$

Month	Mean (d) (Cfs-days)	Mean (w) (Cfs-days)	Sample t	5 % t	Null Hypothesis
Oct	3502	4607	-1.76	-1.67	reject
Nov	2887	3385	-1.66	-1.68	accept
Dec	2554	2905	-1.59	-1.68	accept
Jan	2340	2721	-1.96	-1.68	reject
Feb	2026	2312	-1.88	-1.68	reject
Mar	2312	2551	-1.53	-1.68	accept
Apr	6182	5301	1.14	-1.67	accept
May	23454	25990	-0.96	-1.67	accept
Jun	29925	41299	-3.05	-1.67	reject
Jul	14875	20747	-2.21	-1.67	reject
Aug	5440	7475	-2.60	-1.67	reject
Sep	3427	4972	-3.56	-1.68	reject

* " Mean (d) " = Mean of the Historical Monthly Streamflows for 1925-1952 Water Years

* " Mean (w) " = Mean of the Historical Monthly Streamflows for 1953-1985 Water Years

Table 5.6

Hypothesis Test for Equality of Variances
between Dry and Wet Periods Streamflows
for Goose Creek (13.0825.00)

Null Hypothesis: $\sigma_d^2 = \sigma_w^2$

Alternative Hypothesis: $\sigma_d^2 < \sigma_w^2$

Month	Std (d) (Cfs-days)	Std (w) (Cfs-days)	Sample F	5 % F	Null Hypothesis
Oct	167	234	1.96	1.85	reject
Nov	147	224	2.32	1.85	reject
Dec	182	255	1.96	1.85	reject
Jan	366	920	6.32	1.85	reject
Feb	815	1131	1.93	1.85	reject
Mar	774	906	1.37	1.85	accept
Apr	1487	1353	0.83	1.85	accept
May	2212	3760	2.89	1.85	reject
Jun	940	2281	5.88	1.85	reject
Jul	234	538	5.24	1.85	reject
Aug	170	313	3.37	1.85	reject
Sep	140	231	2.70	1.85	reject

* " Std (d) " = Standard Deviation of the Historical Monthly Streamflows for 1925-1952 Water Years

* " Std (w) " = Standard Deviation of the Historical Monthly Streamflows for 1953-1985 Water Years

* Sample F = $Std^2(w)/Std^2(d)$

Table 5.7

Hypothesis Test for Equality of Means
between Dry and Wet Periods Streamflows
for Goose Creek (13.0825.00)

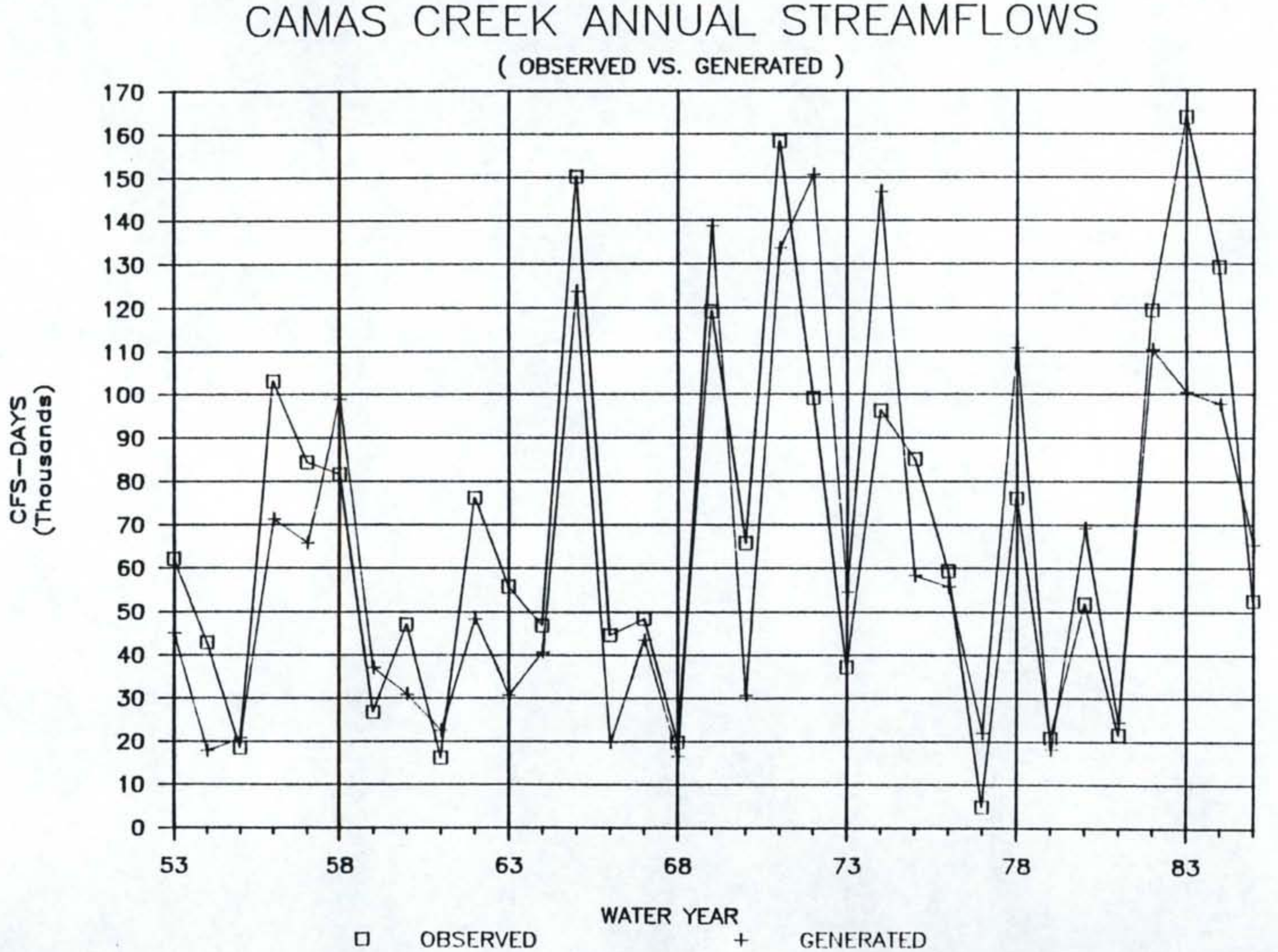
Null Hypothesis: $\mu_d = \mu_w$
Alternative Hypothesis: $\mu_d < \mu_w$

Month	Mean (d) (Cfs-days)	Mean (w) (Cfs-days)	Sample t	5 % t	Null Hypothesis
Oct	456	614	-3.05	-1.67	reject
Nov	642	766	-2.58	-1.67	reject
Dec	660	803	-2.53	-1.67	reject
Jan	723	1149	-2.44	-1.68	reject
Feb	1045	1493	-1.79	-1.67	reject
Mar	1723	2044	-1.47	-1.67	accept
Apr	2935	2972	-0.10	-1.67	accept
May	3902	4923	-1.32	-1.68	accept
Jun	1547	2299	-1.73	-1.68	reject
Jul	418	615	-1.91	-1.68	reject
Aug	262	435	-2.73	-1.68	reject
Sep	222	398	-3.65	-1.67	reject

* " Mean (d) " = Mean of the Historical Monthly Streamflows for 1925-1952 Water Years

* " Mean (w) " = Mean of the Historical Monthly Streamflows for 1953-1985 Water Years

Fig. 5.1


CAMAS CREEK ANNUAL STREAMFLOWS
(OBSERVED VS. GENERATED)
CFS—DAYS (Thousands)
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
53
58
63
68
73
78
83
WATER YEAR
OBSERVED
+ GENERATED

CHAPTER 6

COMPARISONS OF OBSERVED AND SYNTHETIC RECORDS

1. Introduction

A detailed comparison and analysis of the synthetic and observed time series for Camas Creek is required to make critical observations relative to the general model performance and specific effects of groundwater use within this basin. This chapter presents comparisons of the observed and synthetic records. The topics discussed include the statistical analysis of the two series, the seasonal characteristics, and trends in streamflow change.

2. Statistical Analysis

Statistical comparisons (mean, variance, skewness) were made between the observed and synthetic monthly and annual time series.

The F-statistic (for the variance , σ_h^2 , of the observed time series and the variance, σ_g^2, of the synthetic time series) was used to test the null hypothesis, $H_0 : \sigma_h^2 = \sigma_g^2$, and the alternative hypothesis, $H_a : \sigma_h^2 > \sigma_g^2$, for the two series. At the 5 % level of significance, the null hypothesis was rejected for eight of the twelve months (Table 6.1). However, the null hypothesis failed to reject the variance test of the annual (monthly sum) series (Table 6.1). Therefore, it was seen that although the observed time series was significantly more variable than the simulated time series based on monthly streamflows for many months, the monthly variability did not significantly affect the variability of the annual time series.

The paired mean difference t-statistic (between the mean, μ_h, of the observed time series and the mean, μ_g ,of the synthetic time series) was

Table 6.1

Hypothesis Test for Equality of Variances
between Two Monthly Series
(for 1953 -1985 Water Years)

Null Hypothesis: $\sigma_h^2 = \sigma_g^2$
Alternative Hypothesis: $\sigma_h^2 < \sigma_g^2$

Month	Years	Std (h) (Cfs-days)	Std (g) (Cfs-days)	Sample F	5 % F	Null Hypothesis
Oct	33	292	109	7.20	1.84	reject
Nov	33	520	453	1.32	1.84	accept
Dec	33	2339	1586	2.17	1.84	reject
Jan	33	1303	367	12.60	1.84	reject
Feb	33	5465	1420	14.81	1.84	reject
Mar	33	9858	4396	5.03	1.84	reject
Apr	33	22906	27003	0.72	1.84	accept
May	33	12139	14877	0.67	1.84	accept
Jun	33	4484	4375	1.05	1.84	accept
Jul	33	1231	741	2.76	1.84	reject
Aug	33	249	118	4.44	1.84	reject
Sep	33	175	111	2.45	1.84	reject
Ann	33	42808	42441	1.02	1.84	accept

* " Std (h) " = Standard Deviation of the Historical Monthly Streamflows

* " Std (g) " = Standard Deviation of the Generated Monthly Streamflows

* Sample F = $Std^2 (h)/Std^2 (g)$

tested as the null hypothesis, $H_0 : \mu_h - \mu_g = D_0 = 0$, and the alternative hypothesis, $H_a : \mu_h - \mu_g = D_0 > 0$, on the two series. The results (Table 6.2) show that the means of the simulated streamflows of October, November, January, and July were significantly lower than those of the observed streamflows of the same months at the 5 % level of significance.

Coefficients of skewness for the historical monthly streamflows and the generated monthly streamflows are compared in Table O.1. In general, the coefficients of the two time series were close to each other.

The above monthly and annual statistical tests applied to the difference between two time series showed that the synthetic monthly records are lower than the observed monthly records for four months. However, the means of the simulated streamflows of the other months (except April) were also lower (although test results shows that they are not significantly lower than the means of the observed streamflows, some of them are very close to the critical value of the 5 % level of significance) than those of the observed streamflows of the same months. A statistical test for the seasonal time series may give a more clear distinction regarding whether the two series are different.

3. Seasonal Characteristics

To portray seasonal differences in the time series and to determine how these are related to the seasonal distribution of irrigation well development, the monthly data were grouped into four seasons. To make the seasonal groupings, the beginning and ending months of the irrigation pumping period were given priority consideration. Because irrigation pumping begins in May and ends in October in the Camas Creek basin, the month of May was regarded as the first month of the summer season and

Table 6.2

Hypothesis Test for Paired Mean Difference
between Two Monthly Series
(for 1953 -1985 Water Years, Streamflow in cfs-days)

Null Hypothesis: $\mu_h - \mu_g = D_o = 0$
Alternative Hypothesis: $\mu_h - \mu_g = D_o > 0$

Month	Years	Mean	Std Error	Sample t	5 % t	Null Hypothesis
Oct	33	100	38	2.60	1.693	reject
Nov	33	177	35	4.94	1.693	reject
Dec	33	267	494	0.54	1.693	accept
Jan	33	505	229	2.20	1.693	reject
Feb	33	992	884	1.12	1.693	accept
Mar	33	2181	1288	1.69	1.693	accept
Apr	33	-992	3867	-0.26	1.693	accept
May	33	829	1653	0.50	1.693	accept
Jun	33	461	456	1.01	1.693	accept
Jul	33	391	132	2.95	1.693	reject
Aug	33	42	30	1.41	1.693	accept
Sep	33	37	29	1.26	1.693	accept
Ann	33	4994	4405	1.13	1.693	accept

the month of October regarded as the last month of the fall season. Table 6.3 shows the seasonal grouping for the monthly data.

Table 6.3

Seasonal Distinction for Monthly Data

Season	Months
Spring	February - April
Summer	May - July
Fall	August - October
Winter	November - January

The observed and synthetic time series for each season were calculated and the results are plotted in Fig.6.1 through Fig.6.4.

For each season, a statistical comparison (mean, variance) was performed on the observed and synthetic seasonal time series. F-statistics (for the variance, σ_{sh}^2, of the observed time series and the variance, σ_{sg}^2, of the synthetic time series) were tested using the null hypothesis, $H_0: \sigma_{sh}^2 = \sigma_{sg}^2$, and the alternative hypothesis, $H_a: \sigma_{sh}^2 > \sigma_{sg}^2$, on the two series. At the 5 % level of significance, the null hypotheses were rejected for the fall and winter seasons (Table 6.4). A paired mean difference t-statistic (for the mean, μ_{sh}, of the observed time series and the mean, μ_{sg}, of the synthetic time series) was tested for the null hypothesis, $H_0: \mu_{sh} - \mu_{sg} = D_0 = 0$, and the alternative hypothesis, $H_a: \mu_{sh} - \mu_{sg} = D_0 > 0$, on the two time series. The results (Table 6.5) showed that only the fall season simulated streamflows were significantly lower than the observed streamflows at the 5 % level of significance.

From the monthly, seasonal, and annual paired mean difference tests (Tables 6.2 and 6.5), it can be concluded that although the fall season simulated streamflows are significantly lower than the observed

Fig. 6.1

CAMAS CREEK SPRING SEASON STREAMFLOWS

(OBSERVED VS. GENERATED)

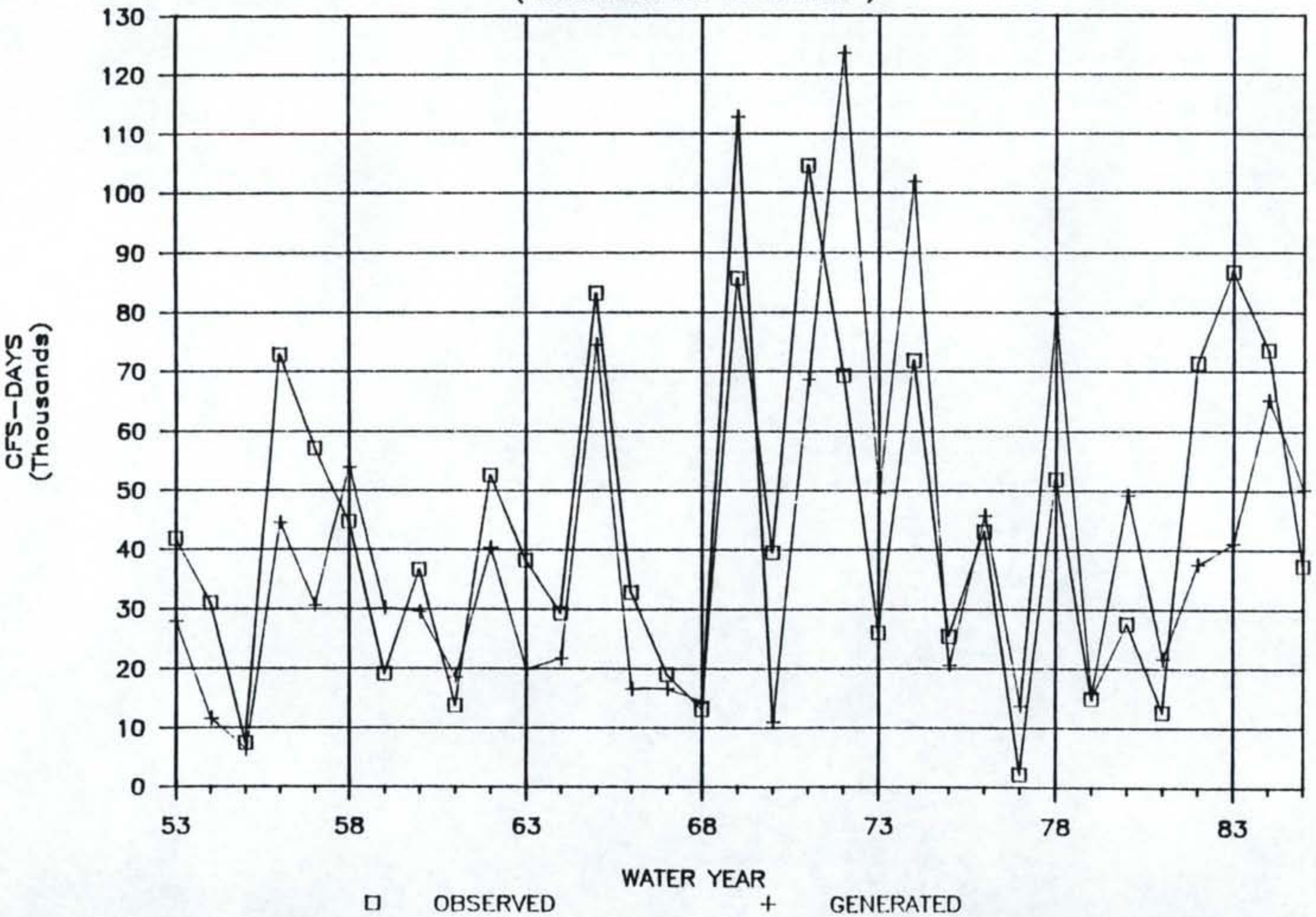


Fig. 6.2

CAMAS CREEK SUMMER SEASON STREAMFLOWS

(OBSERVED VS. GENERATED)

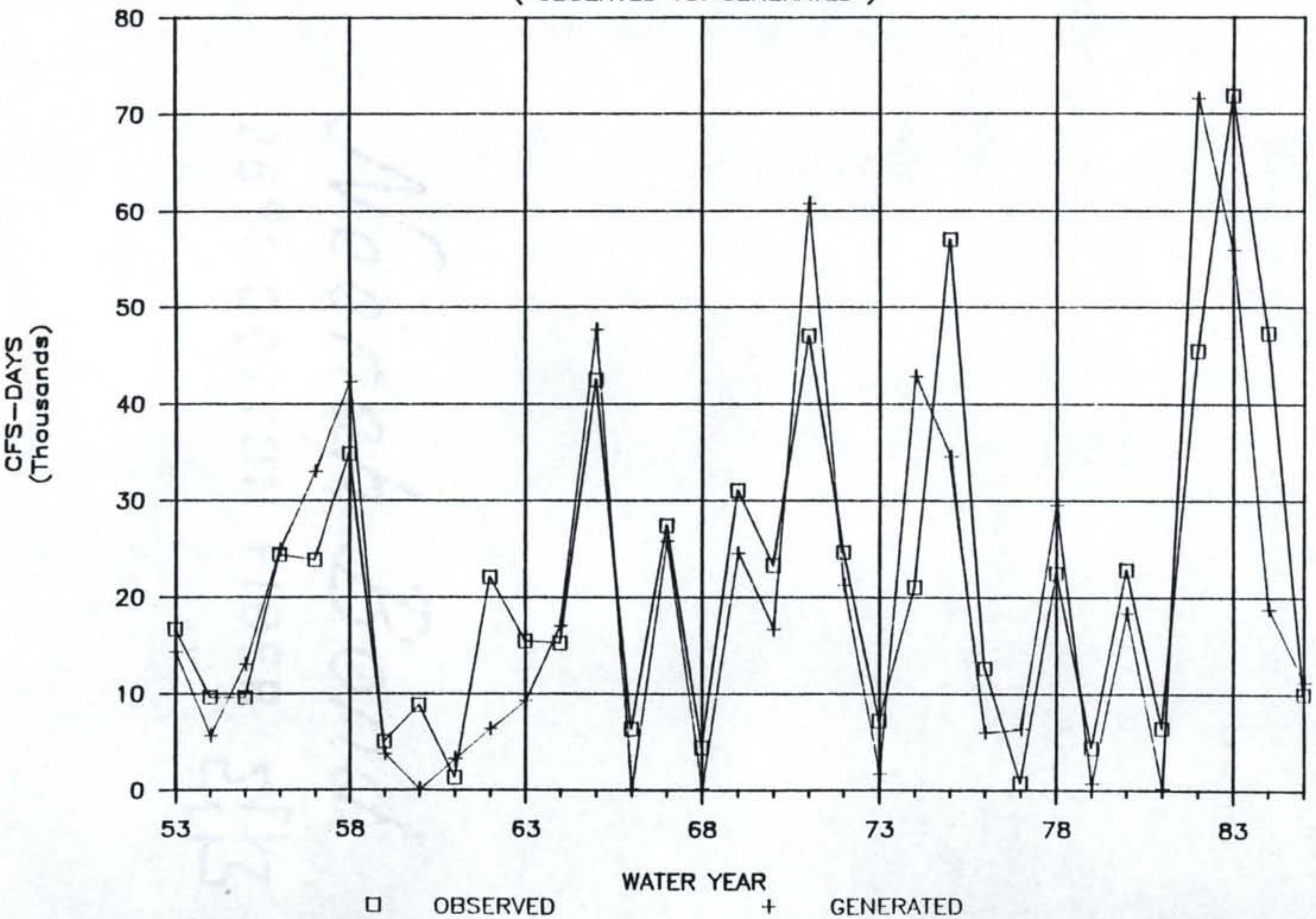


Fig. 6.3

CAMAS CREEK FALL SEASON STREAMFLOWS

(OBSERVED VS. GENERATED)

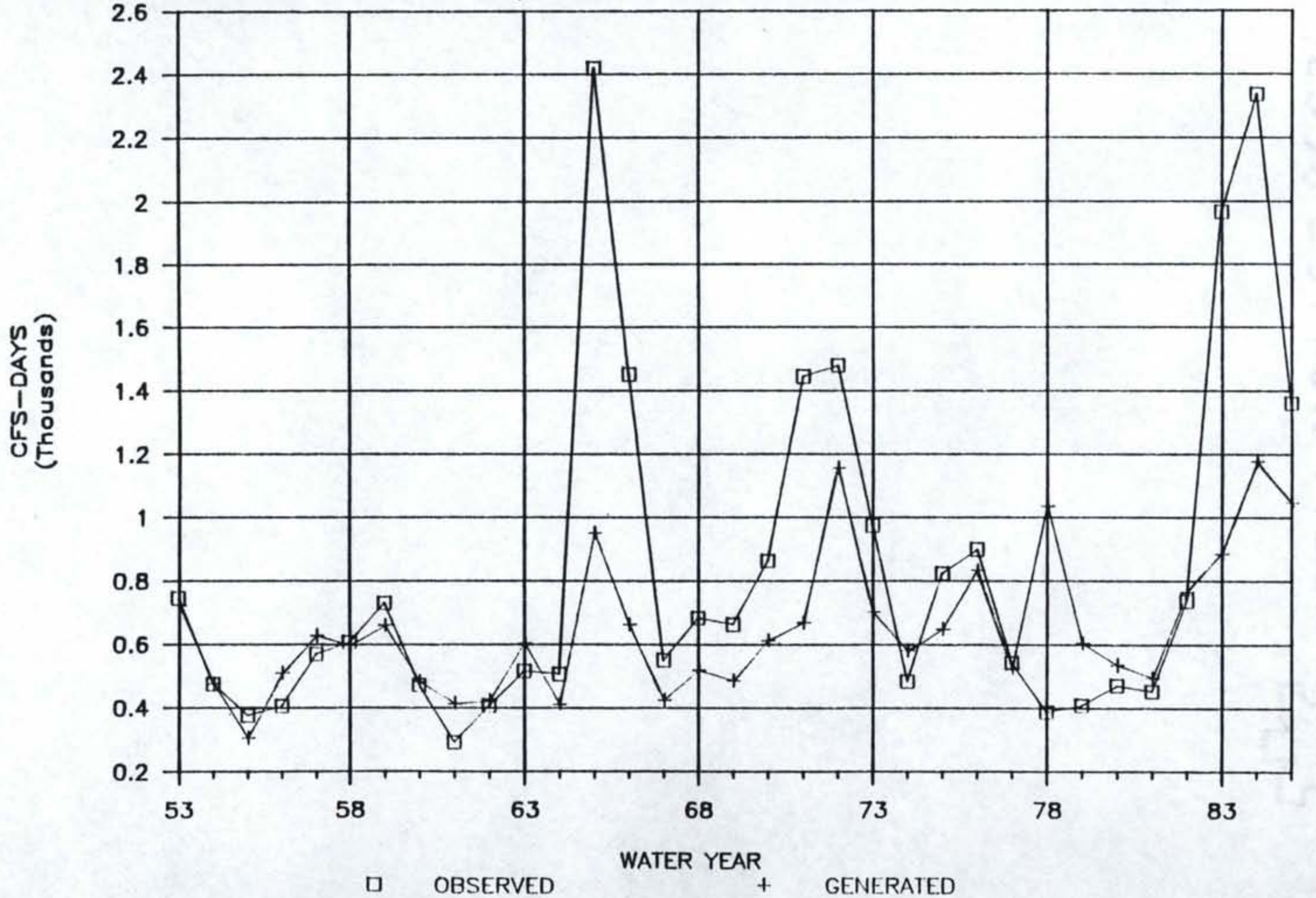


Fig. 6.4

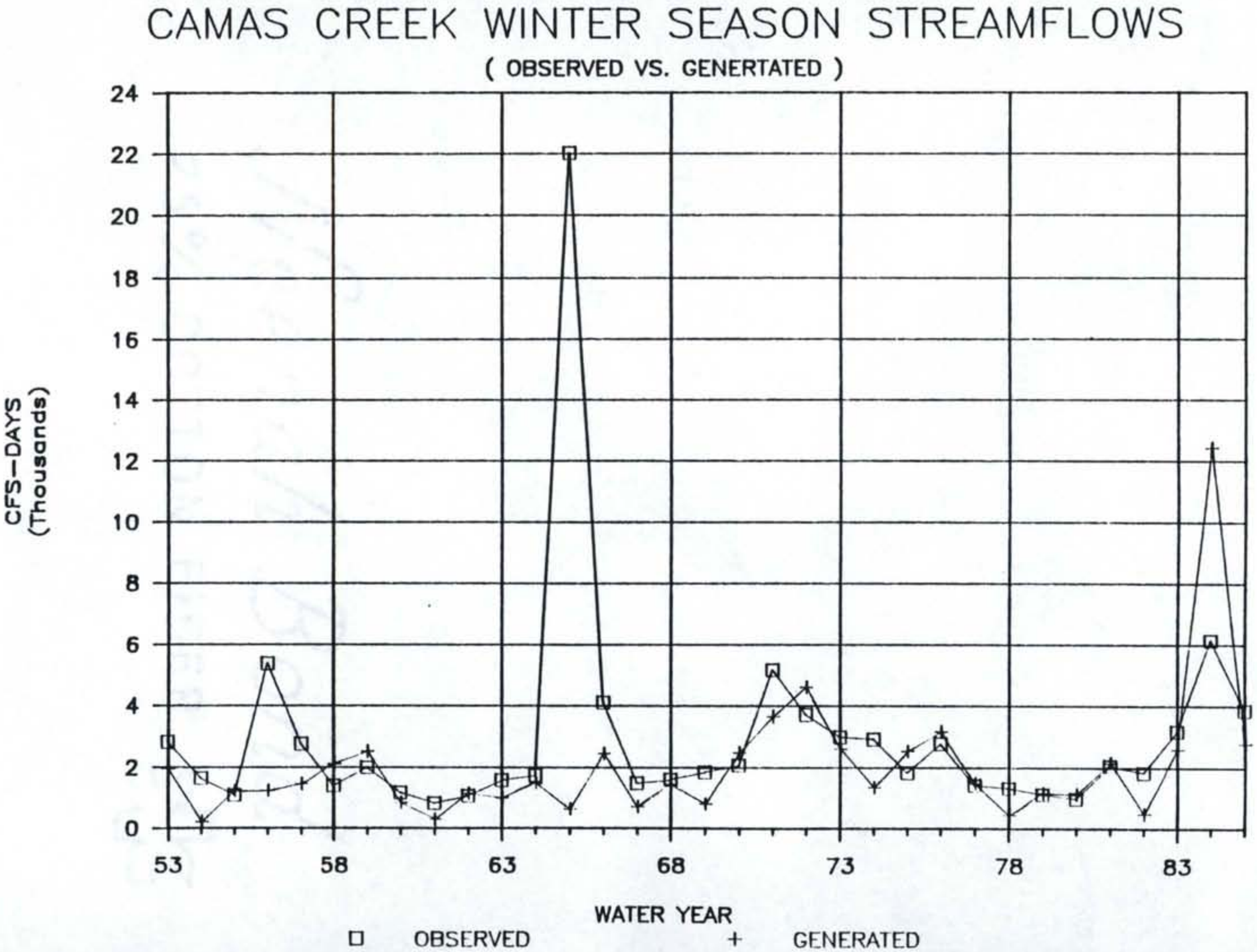

CAMAS CREEK WINTER SEASON STREAMFLOWS
(OBSERVED VS. GENERTATED)
CFS-DAYS
(Thousands)
24
22
20
18
16
14
12
10
8
6
4
2
0
53
58
63
68
73
78
83
WATER YEAR
OBSERVED
GENERATED

Table 6.4

Hypothesis Test for Equality of Variances
between Two Seasonal Series
(for 1953 -1985 Water Years)

Null Hypothesis: $\sigma_{sh}^2 = \sigma_{sg}^2$
Alternative Hypothesis: $\sigma_{sh}^2 > \sigma_{sg}^2$

Season	Years	Std (sh) (Cfs-days)	Std (sg) (Cfs-days)	Sample F	5 % F	Null Hypothesis
Spring	33	26579.38	30132.52	0.78	1.84	accept
Summer	33	17294.99	19244.68	0.81	1.84	accept
Fall	33	559.16	221.11	6.39	1.84	reject
Winter	33	3673.79	2131.90	2.97	1.84	reject

* " Std (sh) " = Standard Deviation of the Historic Monthly Streamflows

* " Std (sg) " = Standard Deviation of the Generated Monthly Streamflows

* Sample F = $Std^2 (sh)/Std^2 (sg)$

Table 6.5

Hypothesis Test for Paired Mean Difference
between Two Seasonal Series
(for 1953 -1985 Water Years, Streamflow in cfs-days)

Null Hypothesis: $\mu_{sh} - \mu_{sg} = D_0 = 0$
Alternative Hypothesis: $\mu_{sh} - \mu_{sg} = D_0 > 0$

Season	Years	Mean	Std Error	Sample t	5 % t	Null Hypothesis
Spring	33	2181.78	3810.24	0.57	1.693	accept
Summer	33	1682.24	1892.62	0.89	1.693	accept
Fall	33	180.54	74.07	2.44	1.693	reject
Winter	33	950.12	692.25	1.37	1.693	accept

streamflows, the difference between the two annual time series is apparently not significant.

4. Trends in Streamflow Change

Trends in streamflow change were examined by analyzing the ratios between the observed and synthetic seasonal and annual time series, and by analyzing the differences between the two time series. In addition to examining the total effects of the trend in streamflow change, cumulative differences between the two series were also analyzed. The analyses of these trends in streamflows are described in the following subsections.

4.1 Analysis of the Ratios between the Observed and Synthetic Flows: To examine the records for trends in streamflow change, ratios between the observed and synthetic monthly flows were calculated. Because some generated monthly flows had zero values, the ratios (observed/synthetic) of those months could not be plotted. Instead, the calculation results of the monthly ratios are presented in Appendix P, Tables P.1 through P.12. The results of the annual (monthly sum) ratio are also presented in Appendix P, Table P.13. To examine trends in seasonal and annual changes of the records, the ratios of the observed and synthetic flows were plotted in Fig.6.5 through Fig.6.9.

4.2 Analysis of the Differences between the Two Series: As an alternative way to examine the records for trends in streamflow change, a time series was created by obtaining the monthly differences between the observed and synthetic flows. Plots were prepared for the difference (observed minus synthetic) versus water year for each of the twelve monthly flows in Fig.P.1 through Fig.P.12. The difference (observed minus synthetic) versus water year for the seasonal and

Fig. 6.5

RATIOS OF SPRING STREAMFLOWS

(OBSERVED / SYNTHETIC)

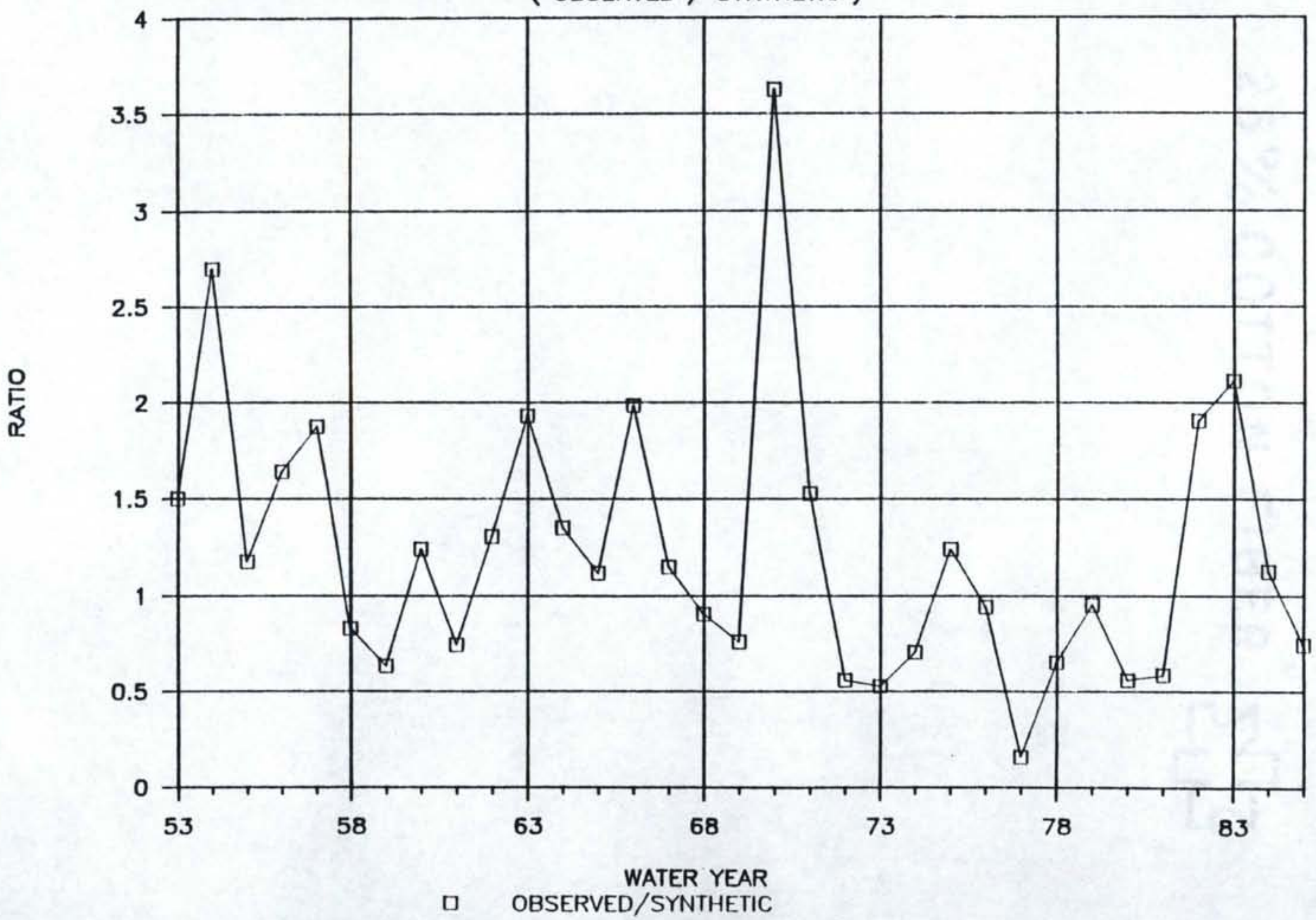


Fig. 6.6

RATIOS OF SUMMER STREAMFLOWS

(OBSERVED / SYNTHETIC)

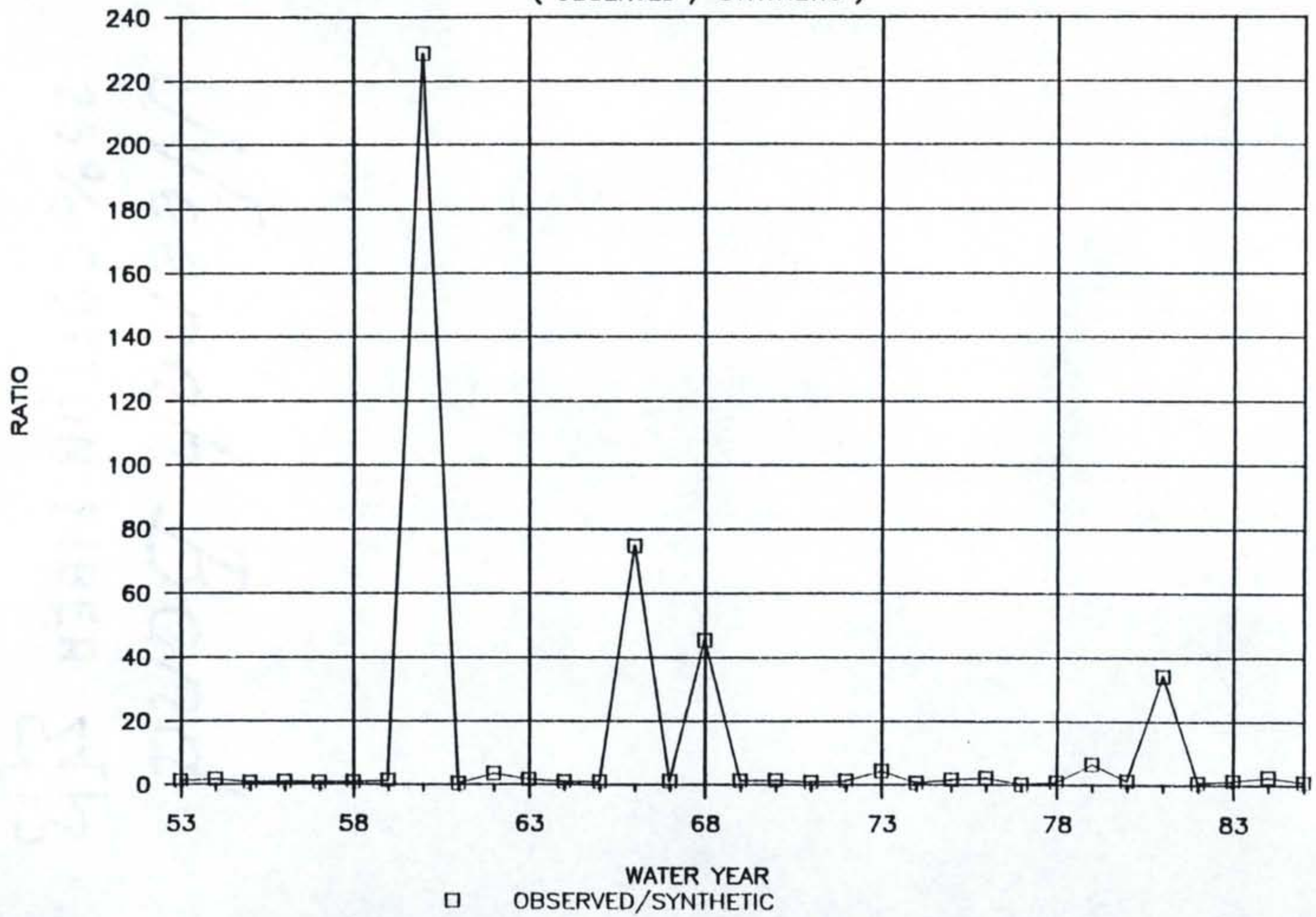


Fig. 6.7

RATIOS OF FALL STREAMFLOWS

(OBSERVED / SYNTHETIC)

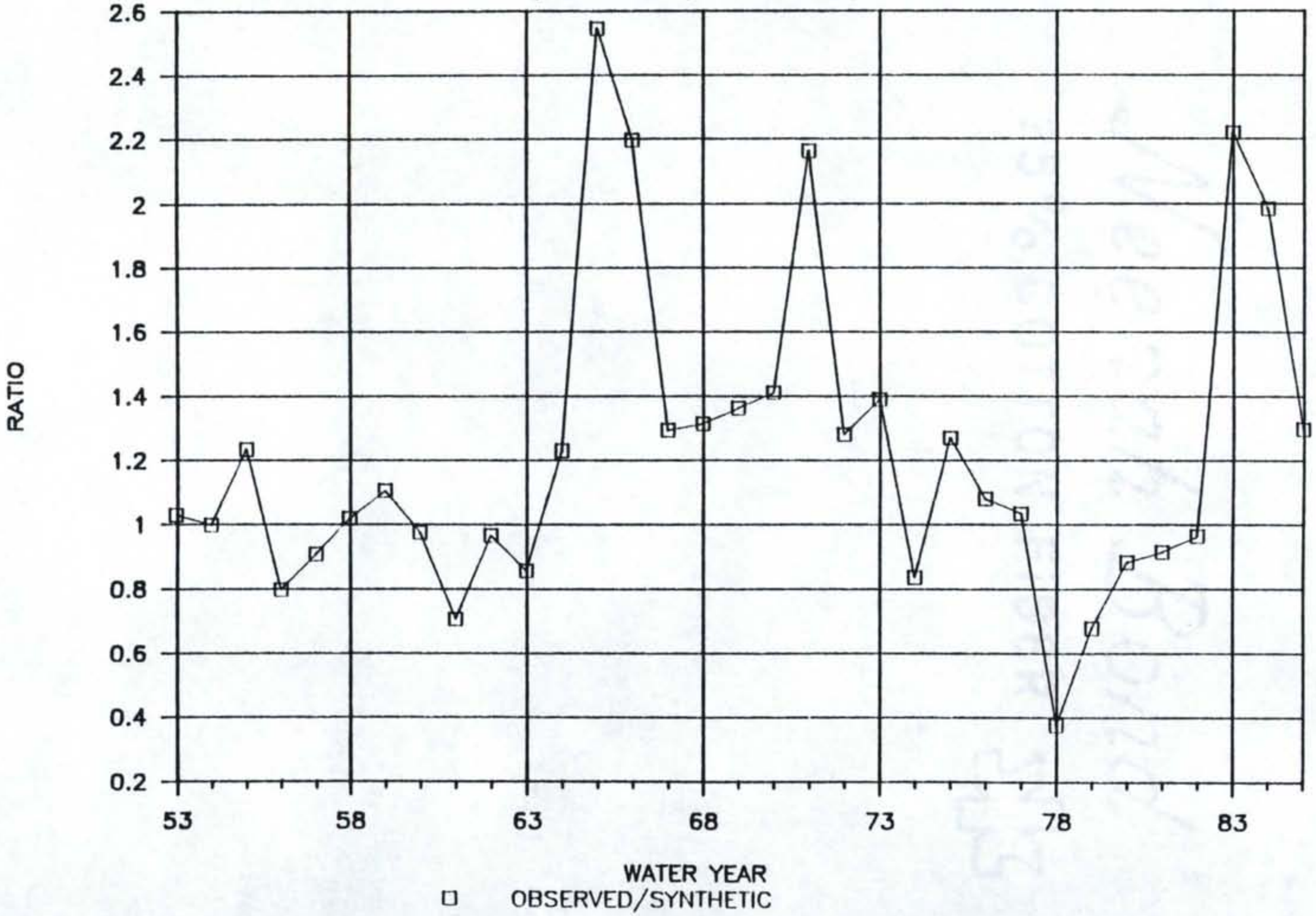


Fig. 6.8

RATIOS OF WINTER STREAMFLOWS

(OBSERVED / SYNTHETIC)

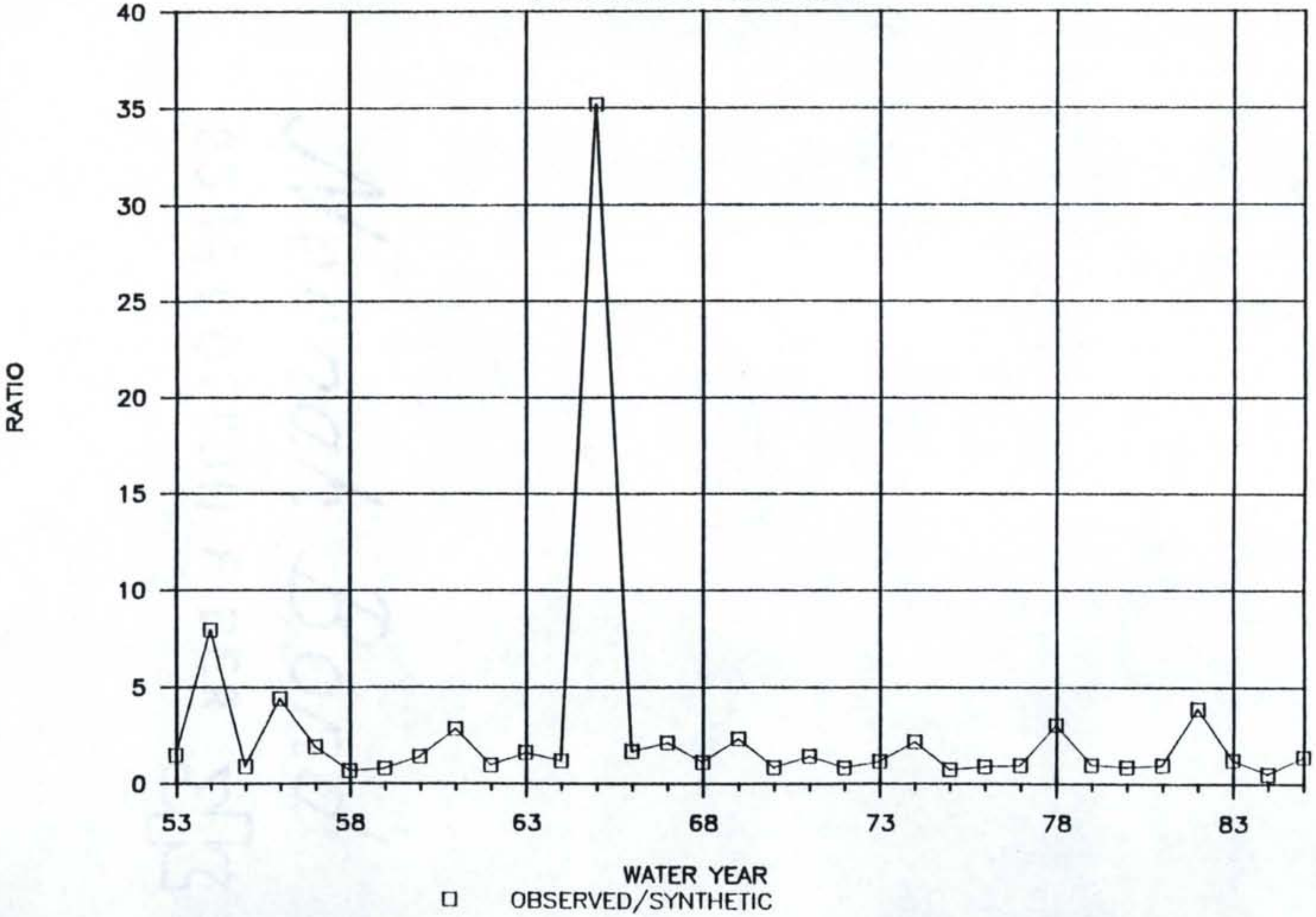
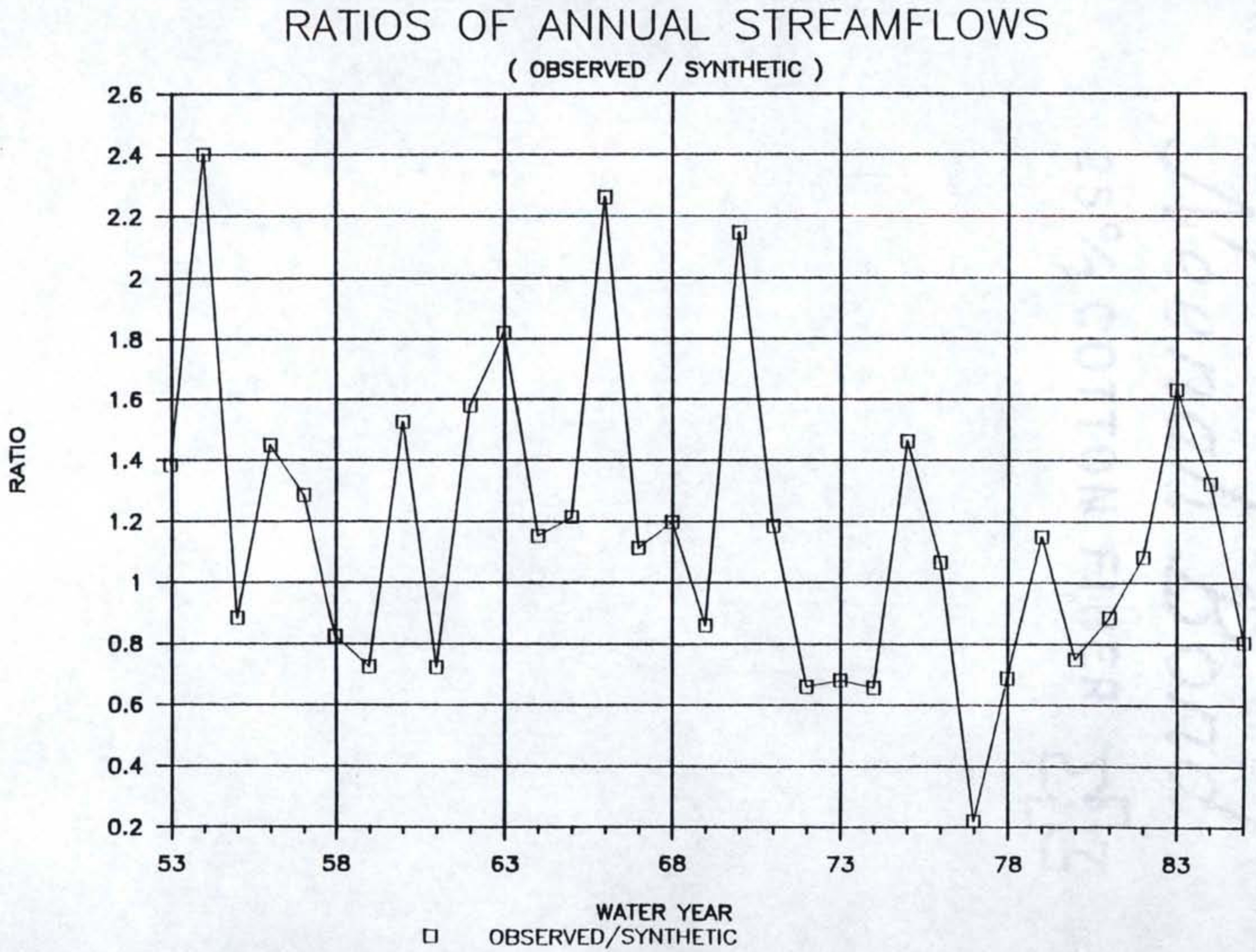


Fig. 6.9


RATIOS OF ANNUAL STREAMFLOWS
(OBSERVED / SYNTHETIC)
RATIO
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
53
58
63
68
73
78
83
WATER YEAR
OBSERVED/SYNTHETIC

annual data are plotted in Fig.6.10 through Fig.6.14. As an examination for the significance of differences of the monthly, seasonal, and annual time series, a t-statistic for the mean difference, μ_d, between the observed and synthetic time series was already tested in the earlier sections of this chapter (see Table 6.2 and Table 6.5). The results showed that the fall season difference between the observed and synthetic time series was significant at the 5 % level.

To determine the linear regression equations, regression analyses were performed for the differences of the seasonal and annual time series. The simple linear regression model (equation 3.1) was applied to represent the relationship between the differences and water years. The following general equation was assumed as the functional relationship to be defined:

$$\hat{Y} = \alpha + \beta X$$

where:

$\hat{Y}$ = estimated seasonal or annual difference

α = Y-intercept

β = linear regression coefficient

X = water year

After estimating the parameters of the model, the significances of the slopes were tested using a t-statistic for the null hypothesis, $H_0: \beta = 0$, and the alternative hypothesis, $H_a: \beta \neq 0$, at the 5 % level of significance. The estimated parameters and the test results for the slopes are summarized in Table 6.6. Table 6.6 shows that there is no trend for the differences of the seasonal and annual time series.

Fig. 6.10

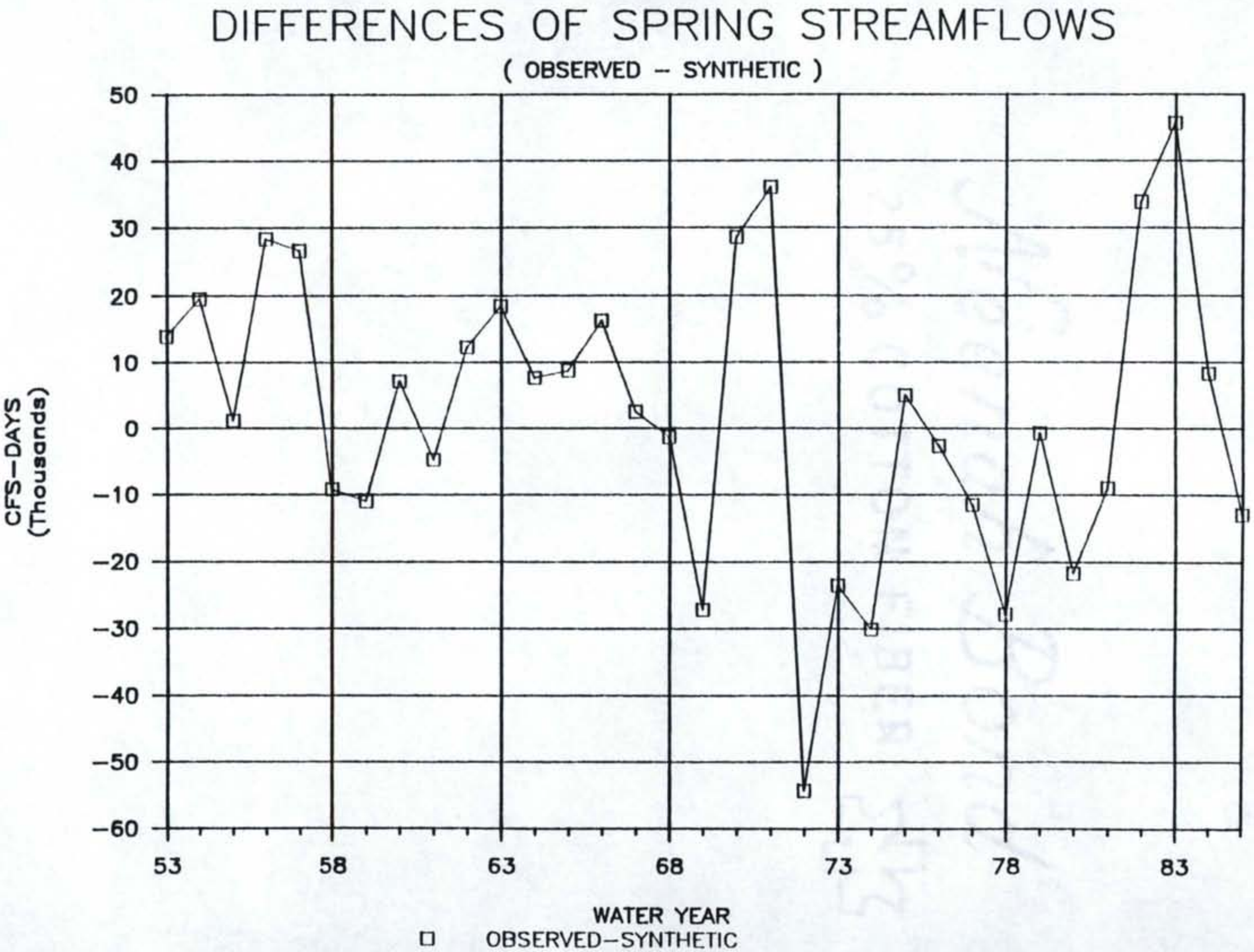

DIFFERENCES OF SPRING STREAMFLOWS
(OBSERVED – SYNTHETIC)
50
40
30
20
10
0
−10
−20
−30
−40
−50
−60
CFS–DAYS
(Thousands)
53
58
63
68
73
78
83
WATER YEAR
OBSERVED–SYNTHETIC

Fig. 6.11

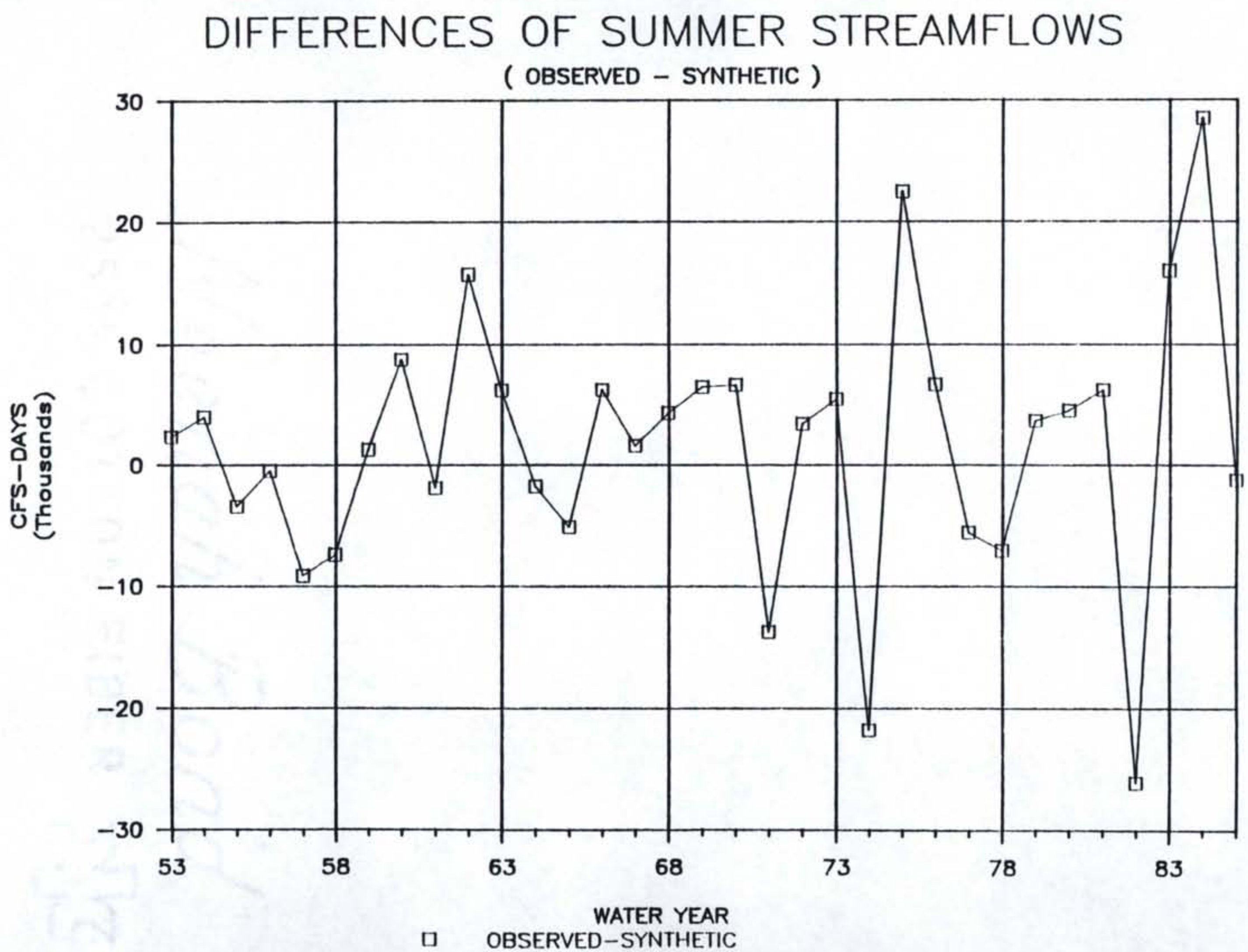

DIFFERENCES OF SUMMER STREAMFLOWS
(OBSERVED – SYNTHETIC)
CFS–DAYS
(Thousands)
30
20
10
0
–10
–20
–30
53
58
63
68
73
78
83
WATER YEAR
OBSERVED–SYNTHETIC

Fig. 6.12

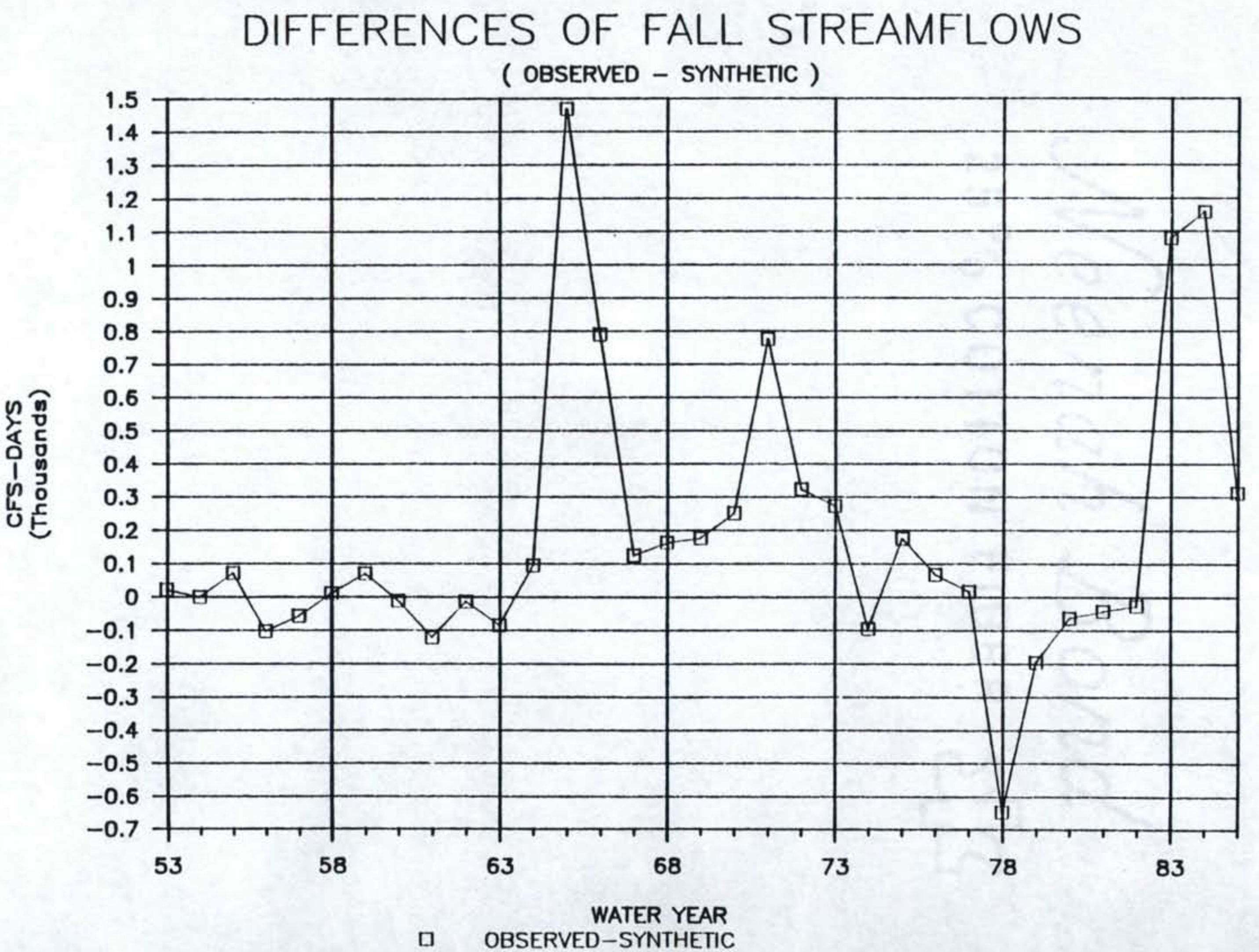
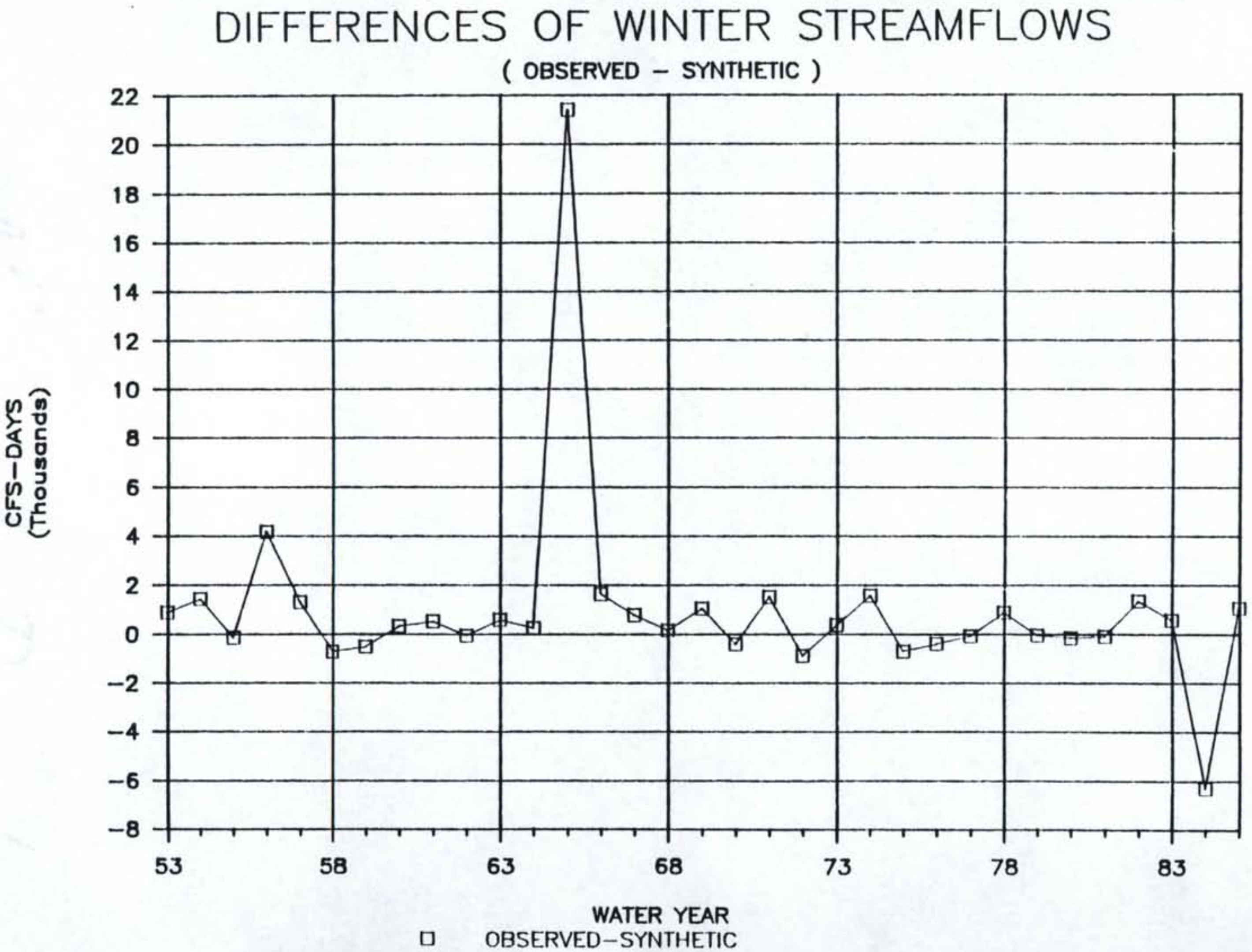

DIFFERENCES OF FALL STREAMFLOWS
(OBSERVED - SYNTHETIC)
CFS-DAYS (Thousands)
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
53
58
63
68
73
78
83
WATER YEAR
OBSERVED-SYNTHETIC

Fig. 6.13



DIFFERENCES OF WINTER STREAMFLOWS
(OBSERVED – SYNTHETIC)
CFS–DAYS
(Thousands)
22
20
18
16
14
12
10
8
6
4
2
0
–2
–4
–6
–8
53
58
63
68
73
78
83
WATER YEAR
OBSERVED–SYNTHETIC

Fig. 6.14

DIFFERENCES OF ANNUAL STREAMFLOWS

(OBSERVED – SYNTHETIC)

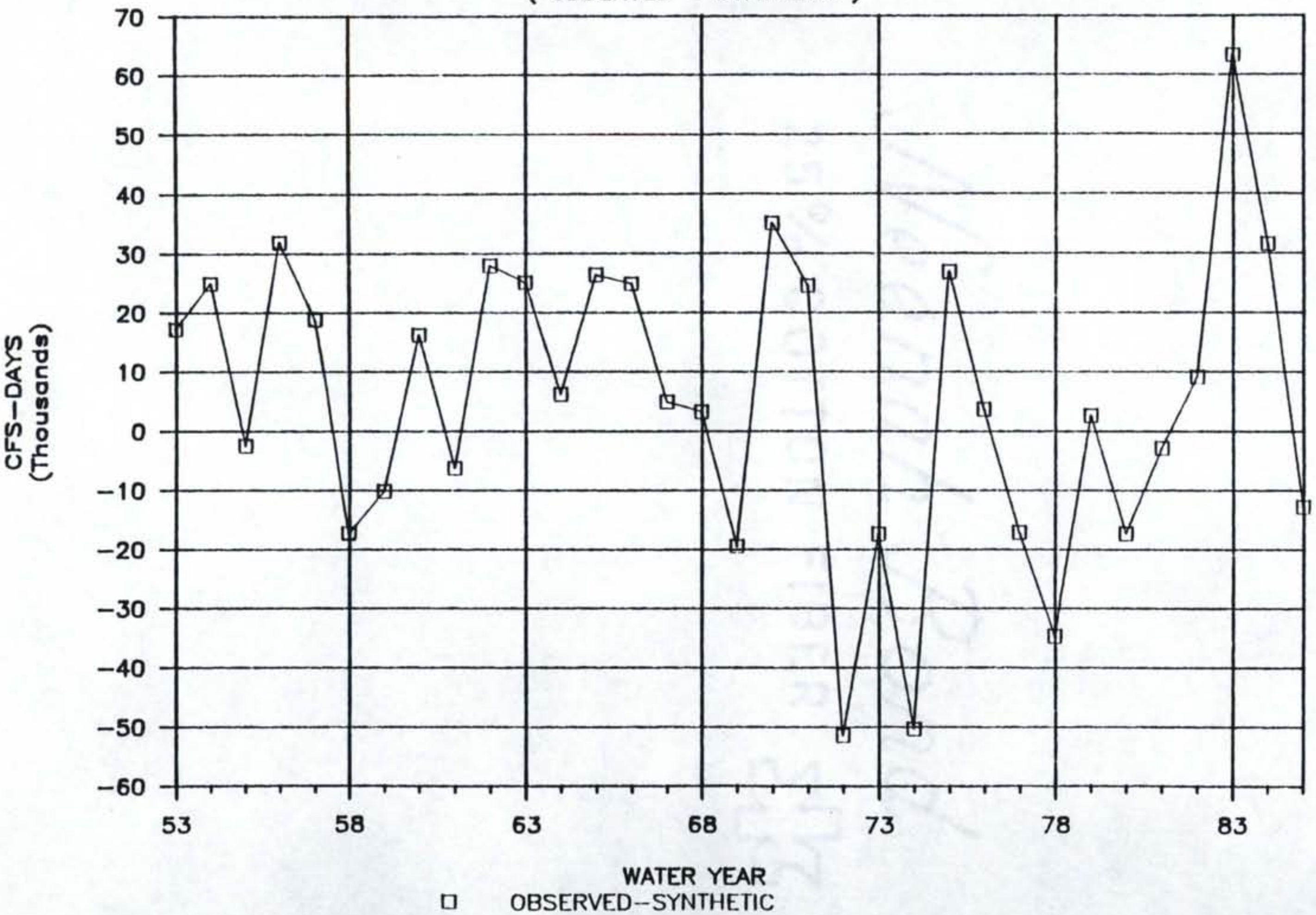


Table 6.6

Estimates for the Simple Linear Regression between Differences and Water Years

Period	α	β	R-square	Null Hypothesis for Slope (β)
Spring	33287	-450.81	0.040	accept
Summer	-6550	119.31	0.011	accept
Fall	-411	8.58	0.038	accept
Winter	6466	-79.94	0.038	accept
Annual	32792	-402.86	0.024	accept

* Null Hypothesis: Slope(β) = 0

* Alternative Hypothesis: Slope(β) ≠ 0

* Level of significance = 5 %

4.3 Analysis of the Cumulative Differences between the Two Series: To examine the total effects of the trend in seasonal and annual streamflow change, cumulative differences between observed and synthetic series were calculated and then plotted in Fig.6.15 through Fig.6.19. Fig. 6.15 shows that the cumulative difference of the spring season has no visual trend of increase in streamflows. Fig. 6.16 and Fig. 6.17 show that although the summer season trend has more variability than the fall season trend, the two seasons have visual trends on increase in streamflows.

For the winter season, the 1965 value of Fig.6.18 completely distorts the trend. This distortion is caused by the poor agreement between modeled and observed flows in December and January of the 1965 water year. Because the 1965 value can be treated as an outlier, it is concluded that there is no trend for the cumulative differences of the winter season. Although the value of 1965 (Fig.6.17) for the fall season also reflects poor agreement between modeled and observed flows of August and September, the value does not affect the trend line as much as the winter season value.

As shown in Fig.6.19, the annual cumulative difference of the 1965 water year is also not greatly affected by the poor agreement of the two seasons. Fig. 6.19 also shows that the annual cumulative difference has not at least a visual trend of increase in streamflows.

From the examination of the total effects of the trend in seasonal and annual streamflow change, it is concluded that the fall season has a trend of increase in streamflows, and that the summer season may have a similar trend.

Fig. 6.15

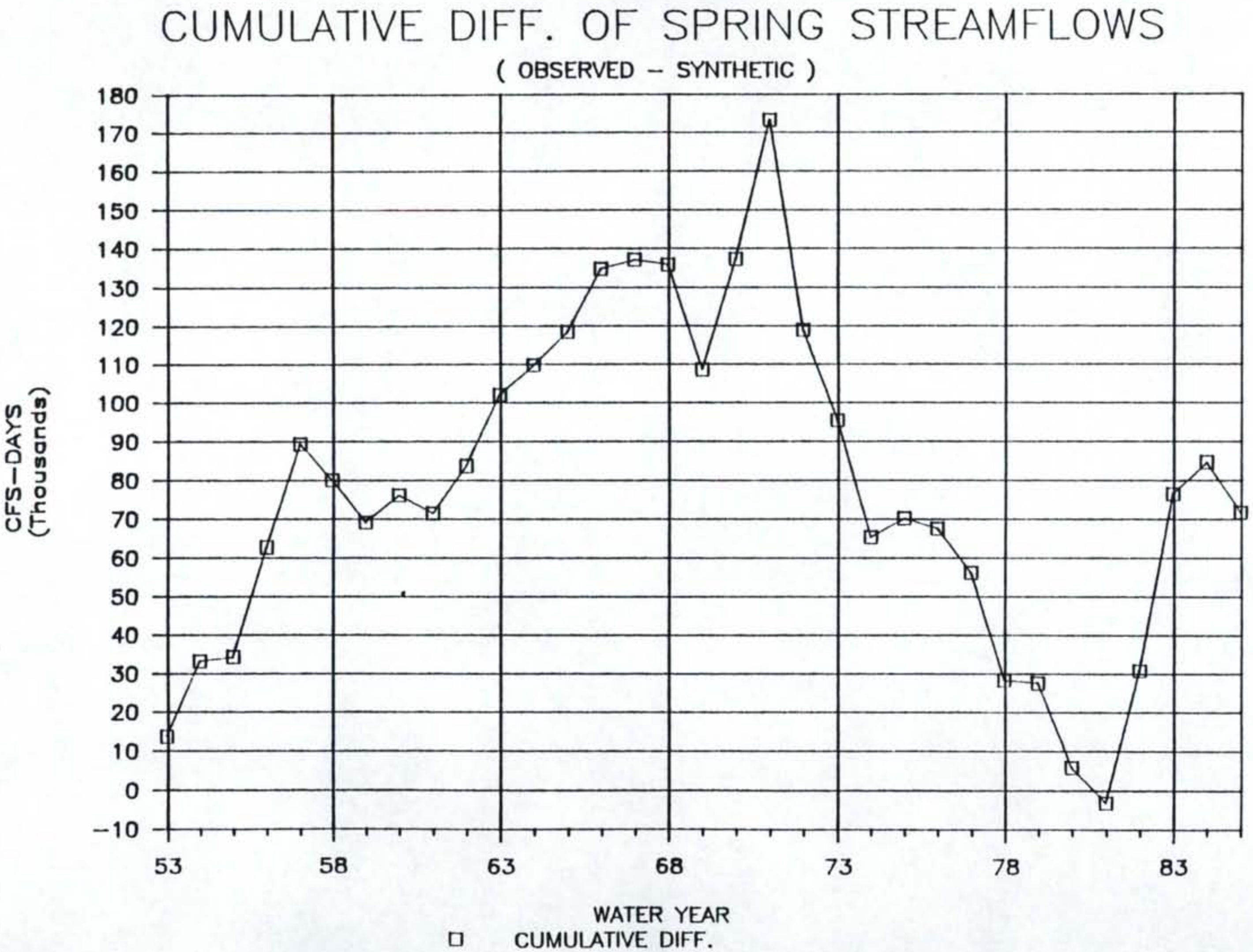

CUMULATIVE DIFF. OF SPRING STREAMFLOWS
(OBSERVED – SYNTHETIC)
CFS–DAYS (Thousands)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
–10
53
58
63
68
73
78
83
WATER YEAR
CUMULATIVE DIFF.

Fig. 6.16

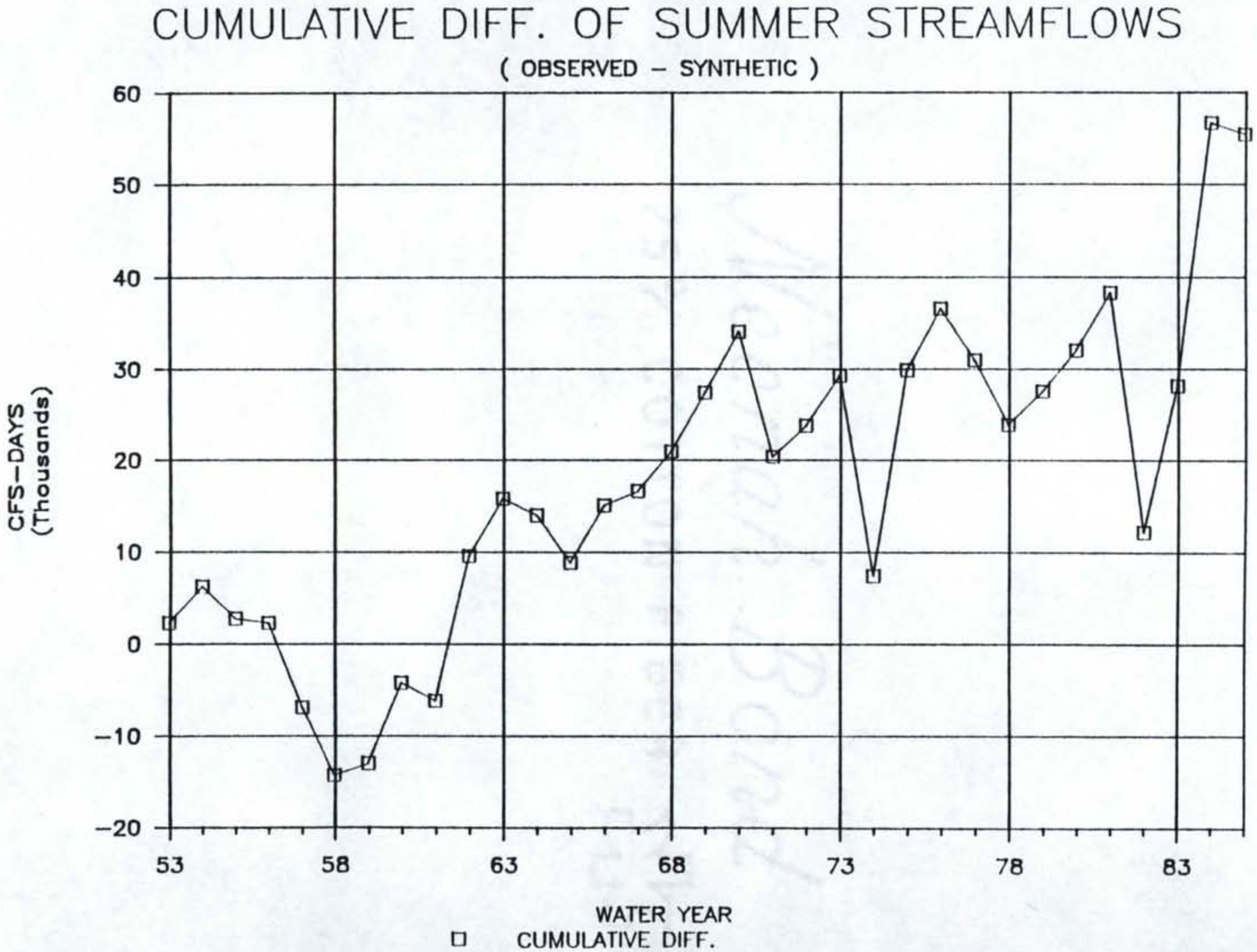

CUMULATIVE DIFF. OF SUMMER STREAMFLOWS
(OBSERVED – SYNTHETIC)
CFS–DAYS
(Thousands)
60
50
40
30
20
10
0
−10
−20
53
58
63
68
73
78
83
WATER YEAR
CUMULATIVE DIFF.

Fig. 6.17

CUMULATIVE DIFF. OF FALL STREAMFLOWS

(OBSERVED – SYNTHETIC)

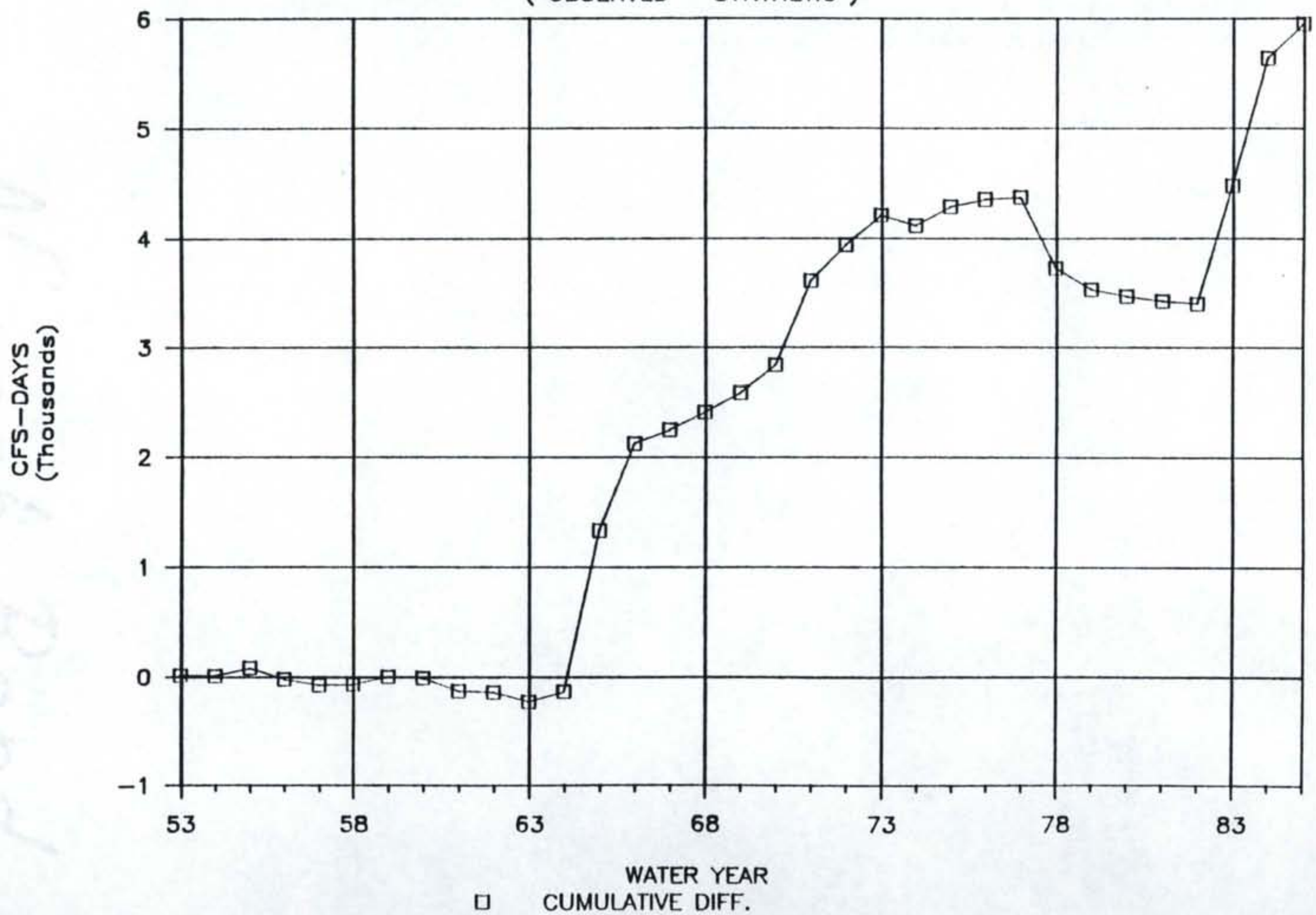


Fig. 6.18

CUMULATIVE DIFF. OF WINTER STREAMFLOWS

(OBSERVED - SYNTHETIC)

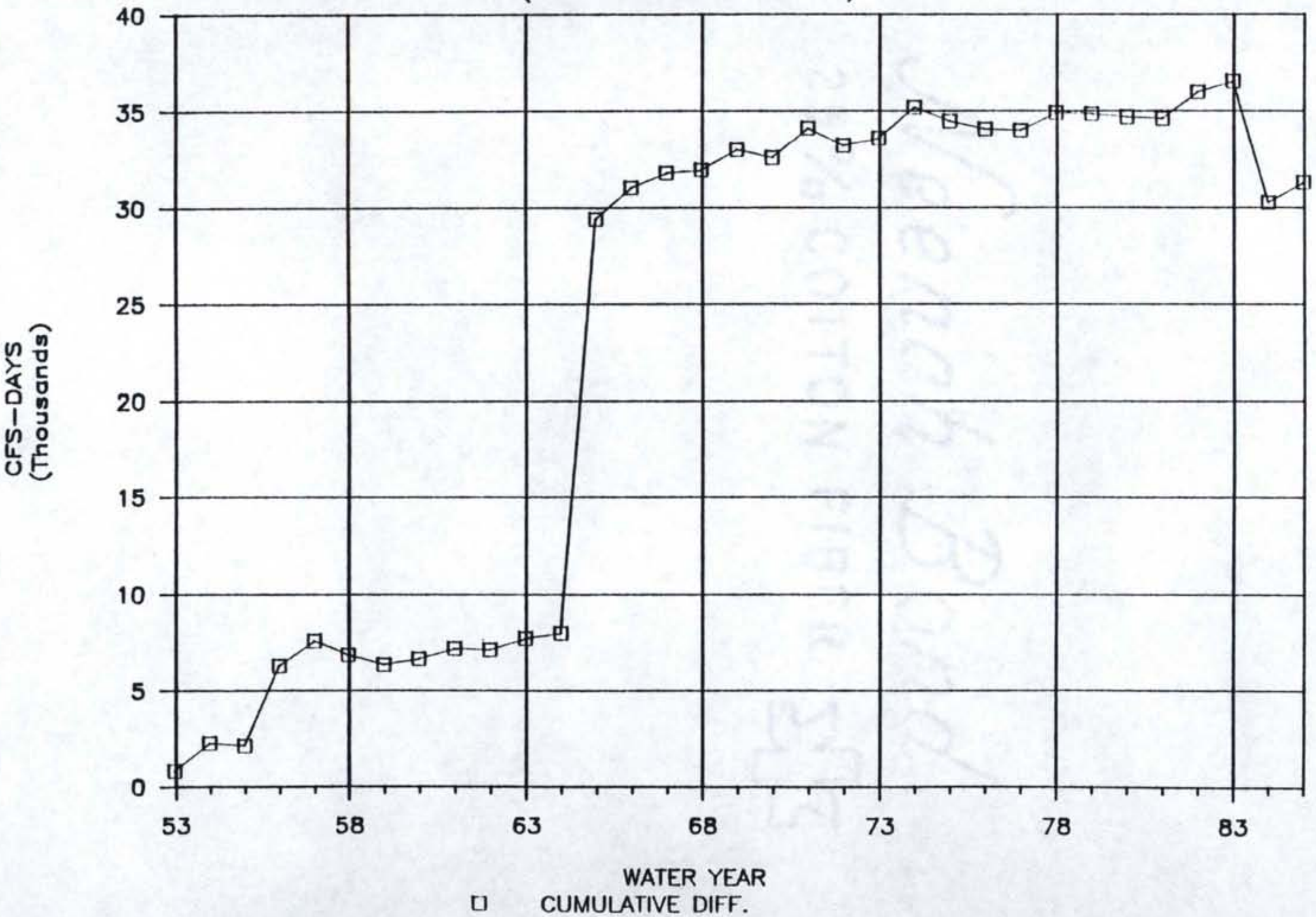
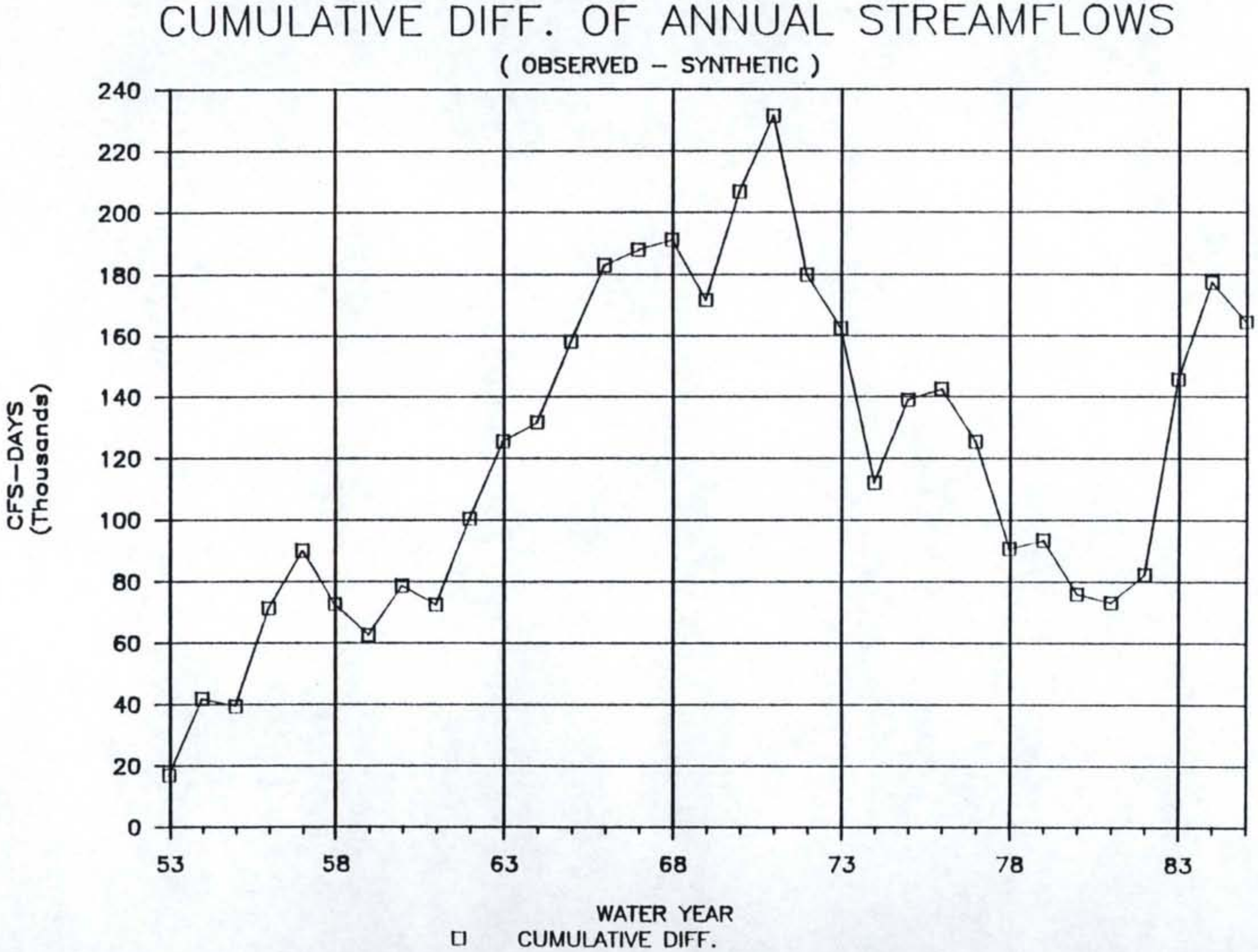


Fig. 6.19



CUMULATIVE DIFF. OF ANNUAL STREAMFLOWS
(OBSERVED – SYNTHETIC)
CFS–DAYS
(Thousands)
240
220
200
180
160
140
120
100
80
60
40
20
0
53
58
63
68
73
78
83
WATER YEAR
CUMULATIVE DIFF.

CHAPTER 7

CONJUNCTIVE USE RELATIONSHIPS

1. Introduction

This chapter discusses the cause-effect relationships between groundwater withdrawal and streamflow change. From the Idaho Department of Water Resources, a chronological history of well development in the Camas Creek basin was obtained. Table Q.1, Appendix Q shows the logs of irrigation wells in the study area from 1953 through 1985 water years. From that information, irrigation well development history in the study area was analyzed in Table Q.2, Appendix Q. Fig.7.1 shows irrigation well development history from 1953 through 1985.

To obtain information concerning an annual time lag between well development and impacts on the Camas Creek streamflow, the time-history of well development was examined and compared to the figures and statistical test results of the previous chapter. Comparisons between the total number of wells and the seasonal and annual streamflow changes were conducted to indicate whether a relationship exists and if it is affected by "wet" or "dry" year conditions.

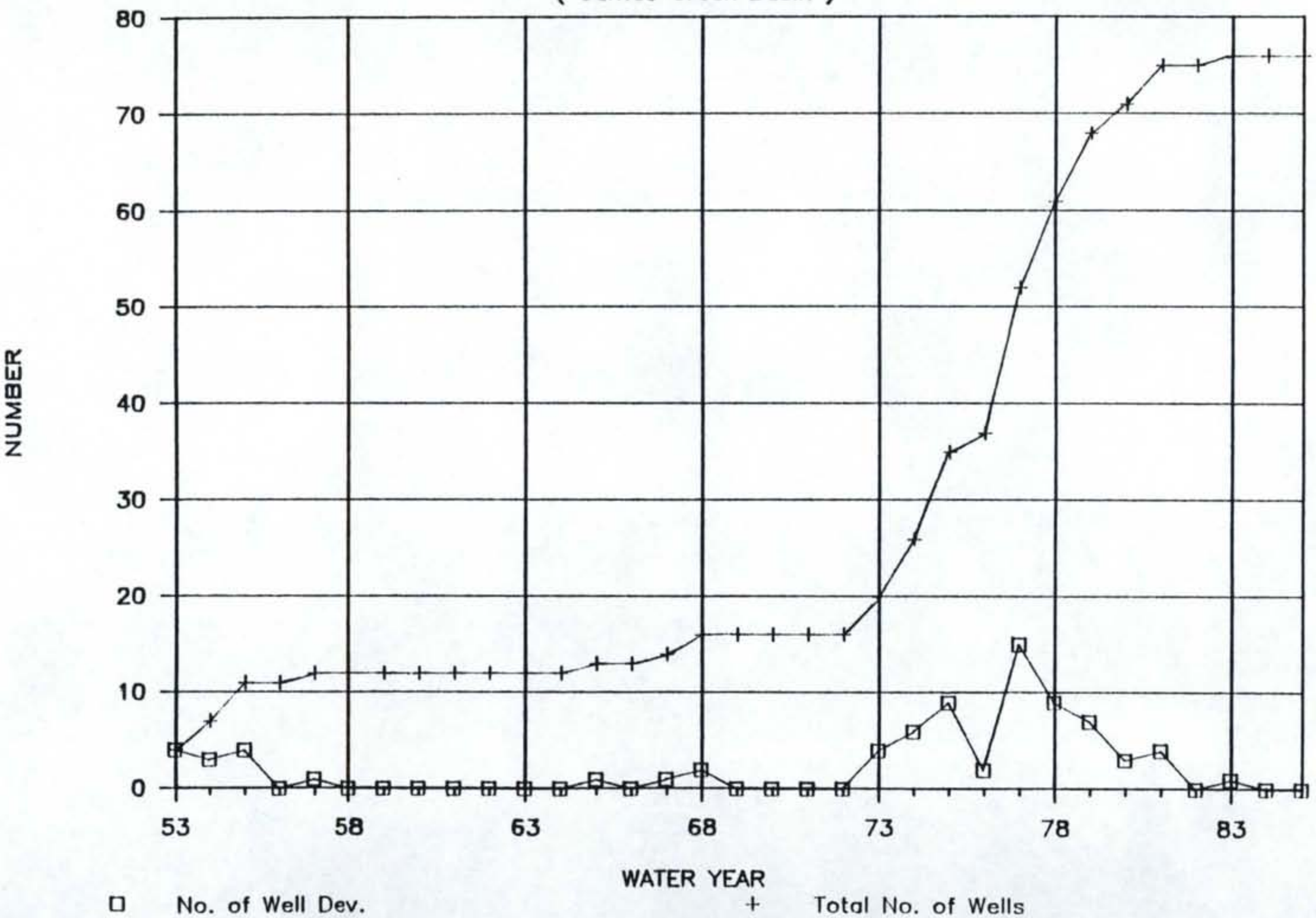
2. Conjunctive Use Relationship

Fig.6.3 and Table 6.5 of the previous chapter show that, generally, the simulated record produced lower streamflows than the observed streamflows. This may be attributed to the fact that most of the large wells have pumped (mainly in the summer season) from deep aquifers with no connection to the surface stream system.

Fig. 7.1

IRRIGATION WELL DEVELOPMENT HISTORY

(Camas Creek Basin)



Previous studies (37,38,51) indicate that the unconfined aquifer extends from about 10 to 40 feet below the land surface and is separated from underlying artesian aquifers by a thick clay layer. Table 7.1 shows that all of the irrigation wells developed in the study area are deeper than 40 feet. These data would support the above conclusion that irrigation return flows contribute to the streamflows.

Table 7.1

Depth of the Irrigation Wells

Depth (feet)	Number of Wells
<70	0
70 - 100	2
100 - 200	14
200 - 300	20
300 - 400	16
400 - 500	14
>500	10
Total	76

<u>2.1 Time Lag between Well Development and Impacts on the Camas Creek Streamflows:</u> Irrigation pumping begins in May (the early part of the irrigation season), reaches a maximum in June and July, and declines through August, September, and October. Therefore, it is concluded that the irrigation return flows pumped in the summer season are contributing to the streamflows in the fall season. For this reason, it can be concluded that the irrigation return flow contribution to streamflows is lagged by one season from the major irrigation pumping season.

Table 6.2 shows that the annual streamflows are not significantly affected by the groundwater withdrawals in the Camas Creek basin. Therefore, it can be concluded that although the

irrigation return flows pumped mainly in the summer season have apparently contributed to the streamflows in the fall season, the contribution doesn't significantly increase the annual streamflows.

A comparison between the observed annual streamflows and the annual differences was conducted to examine whether a relationship exists and is affected by "wet" or "dry" year conditions. The results (Fig.7.2) show that no apparent relationship exists.

2.2 Comparisons between the Total Number of Wells and Annual Changes: To examine the historical pattern of groundwater development and the pattern in streamflow change, comparisons between the total number of wells and the seasonal cumulative differences between the observed and the synthetic series were conducted in Fig.7.3 through Fig.7.6. From Fig.7.3, Fig.7.6, and Fig.7.7, no relationship is seen in the spring and winter seasons, or in the annual data, between the cumulative well development and cumulative streamflow change. For the summer and fall seasons, however, as well development has increased, the streamflows appear to have also increased. This parallel relationship is more noticable in the fall season than in the summer season, as would be expected considering the previously presented results of trend lines and significance tests on the means.

From these results, it is concluded that although the fall season streamflow has apparently increased in a time pattern similar to the increase in groundwater development, the annual streamflow has not been significantly affected by the increase of the streamflow of the fall season.

Fig. 7.2

OBSERVED FLOWS AND ANNUAL DIFFERENCES

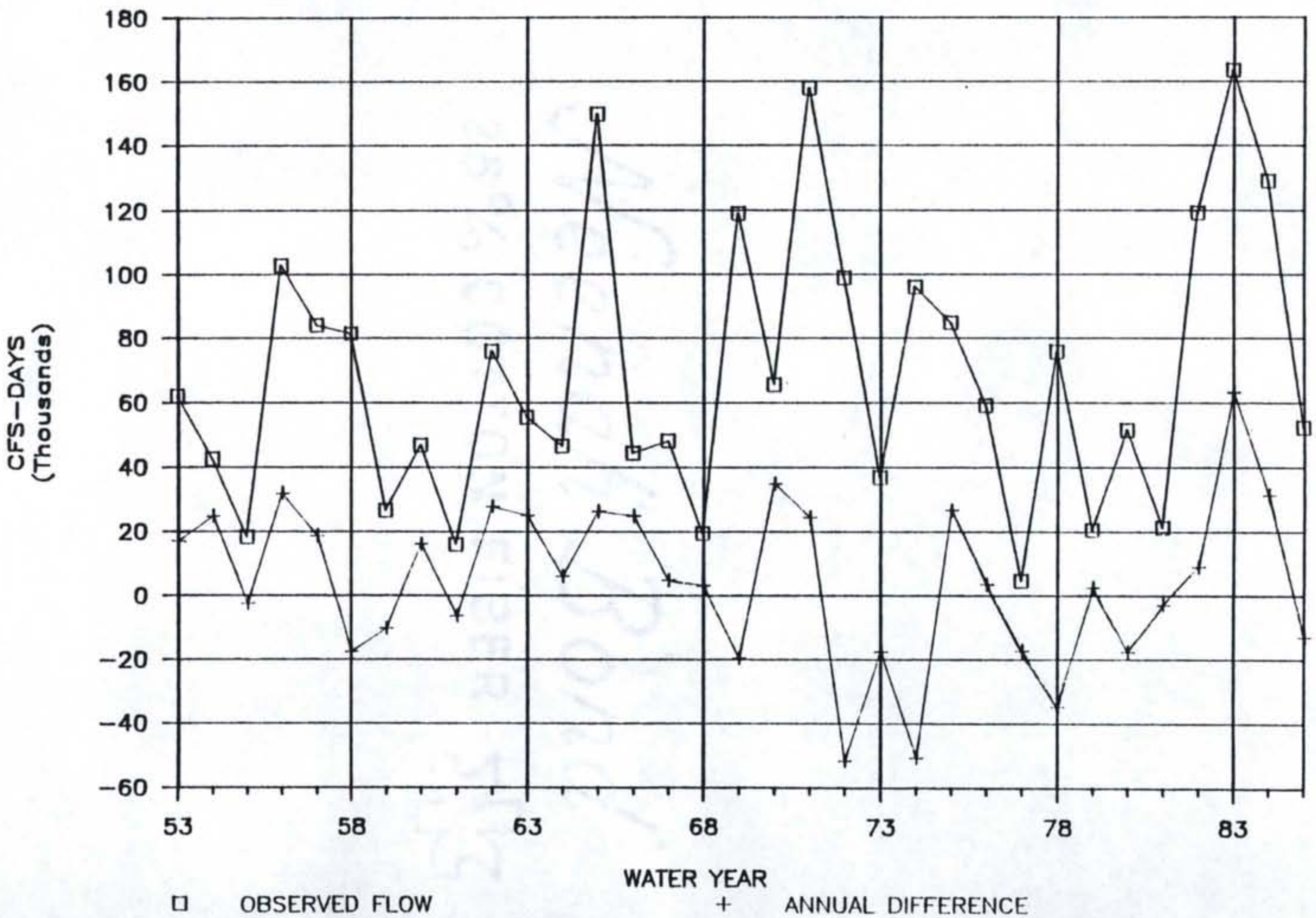


Fig. 7.3

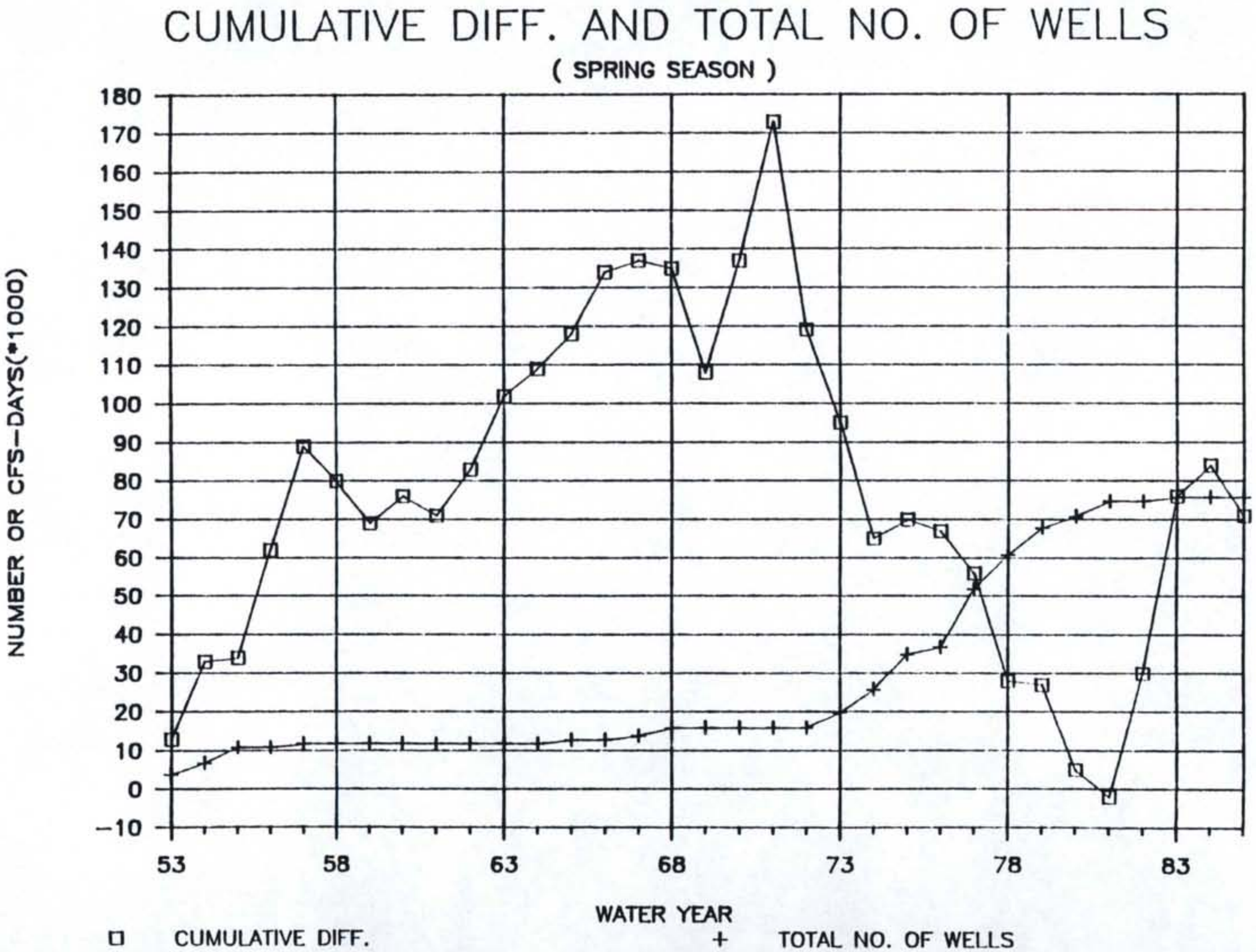

CUMULATIVE DIFF. AND TOTAL NO. OF WELLS
(SPRING SEASON)
NUMBER OR CFS-DAYS(*1000)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
53
58
63
68
73
78
83
WATER YEAR
CUMULATIVE DIFF.
TOTAL NO. OF WELLS

Fig. 7.4

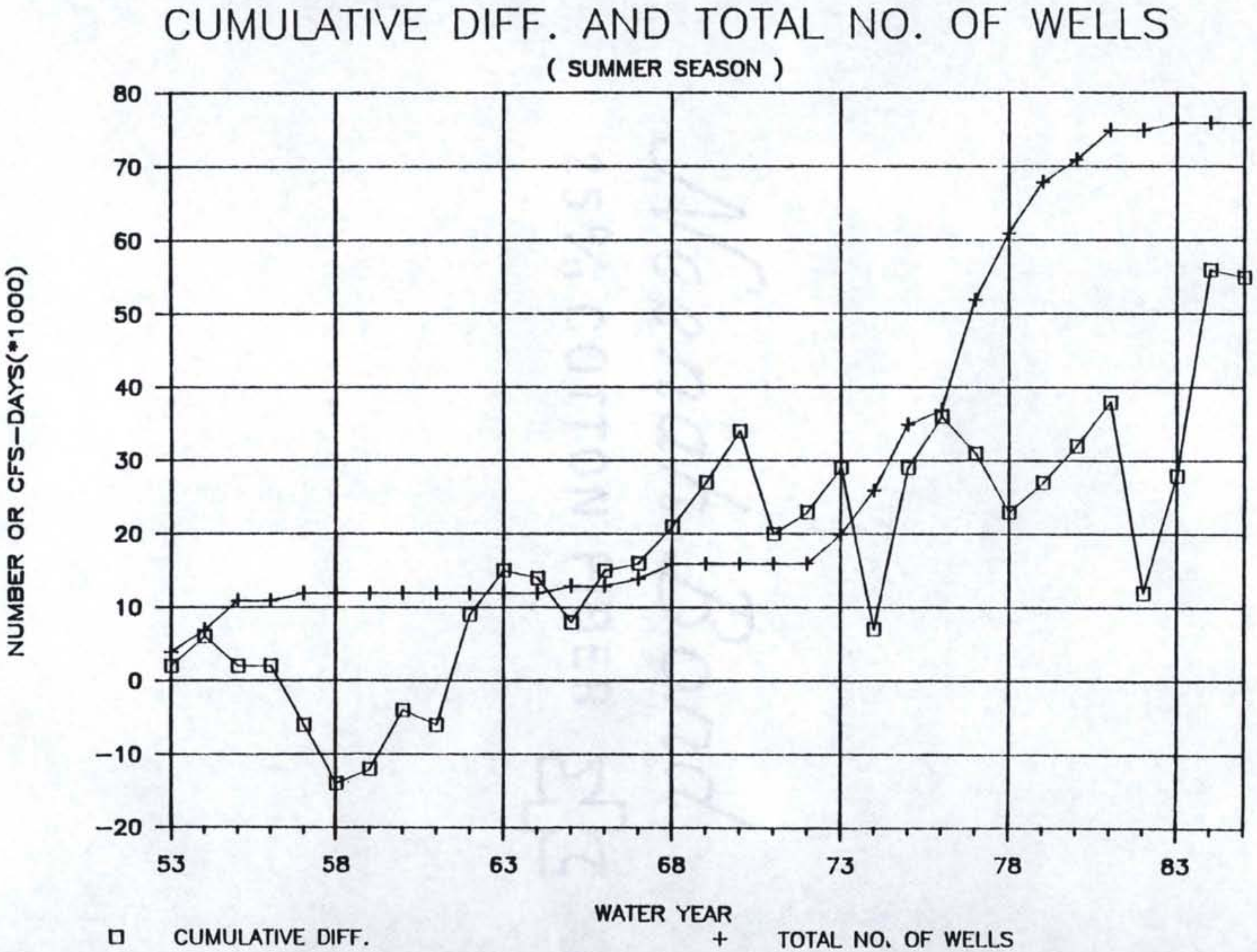
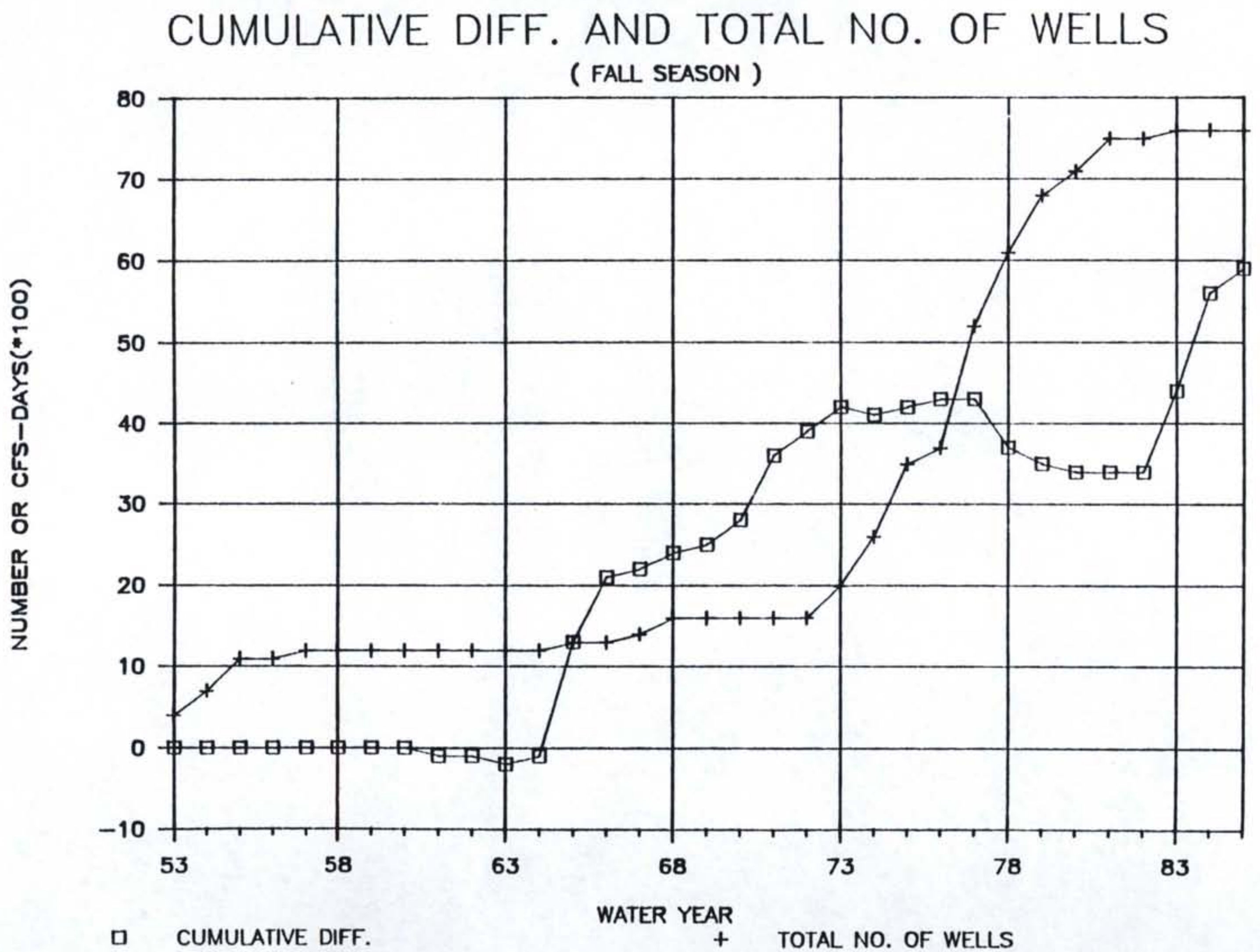

CUMULATIVE DIFF. AND TOTAL NO. OF WELLS
(SUMMER SEASON)
NUMBER OR CFS–DAYS(*1000)
80
70
60
50
40
30
20
10
0
−10
−20
53
58
63
68
73
78
83
WATER YEAR
CUMULATIVE DIFF.
TOTAL NO. OF WELLS

Fig. 7.5



CUMULATIVE DIFF. AND TOTAL NO. OF WELLS
(FALL SEASON)
NUMBER OR CFS-DAYS(*100)
80
70
60
50
40
30
20
10
0
-10
53
58
63
68
73
78
83
WATER YEAR
CUMULATIVE DIFF.
+ TOTAL NO. OF WELLS

Fig. 7.6

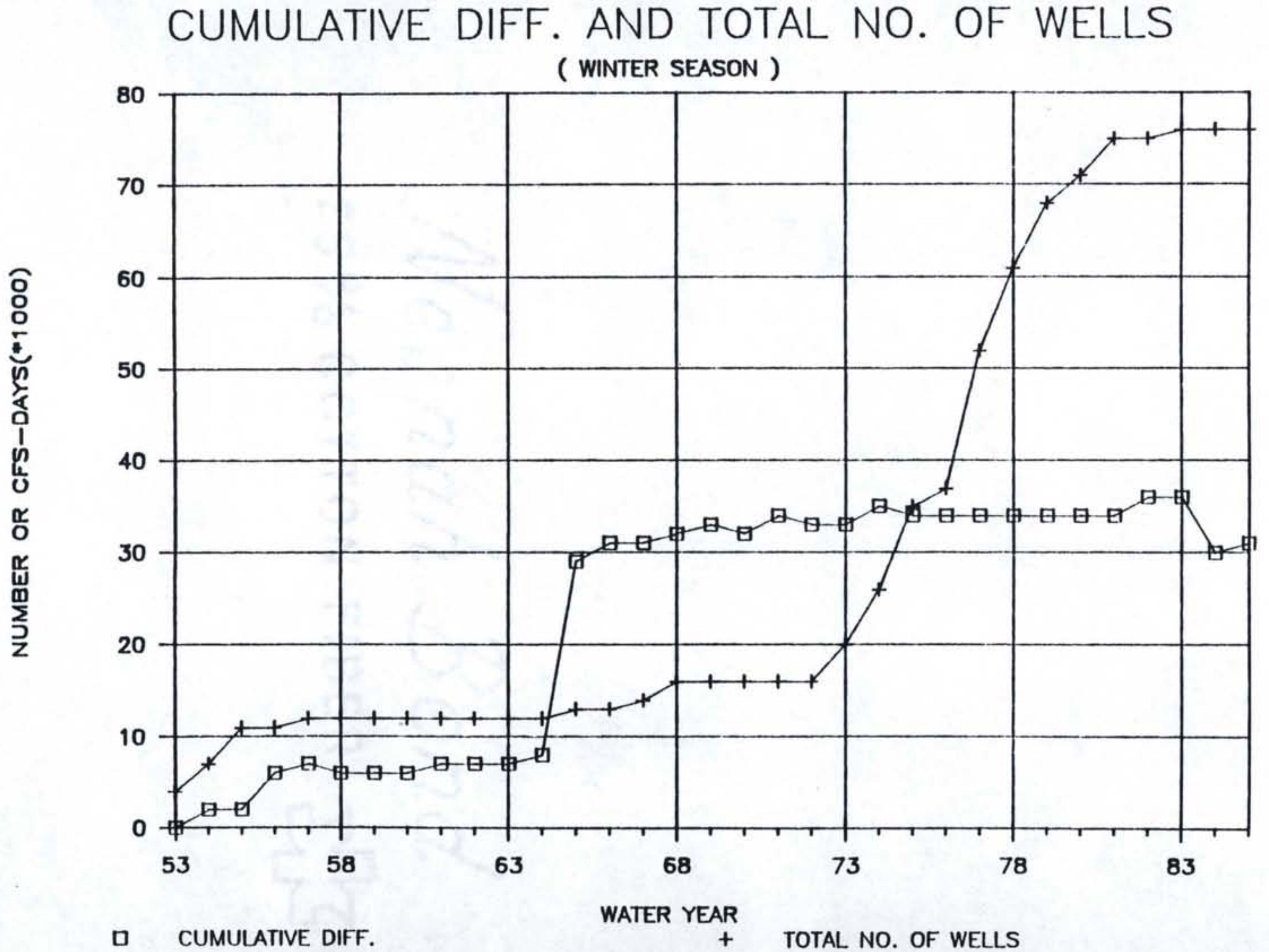
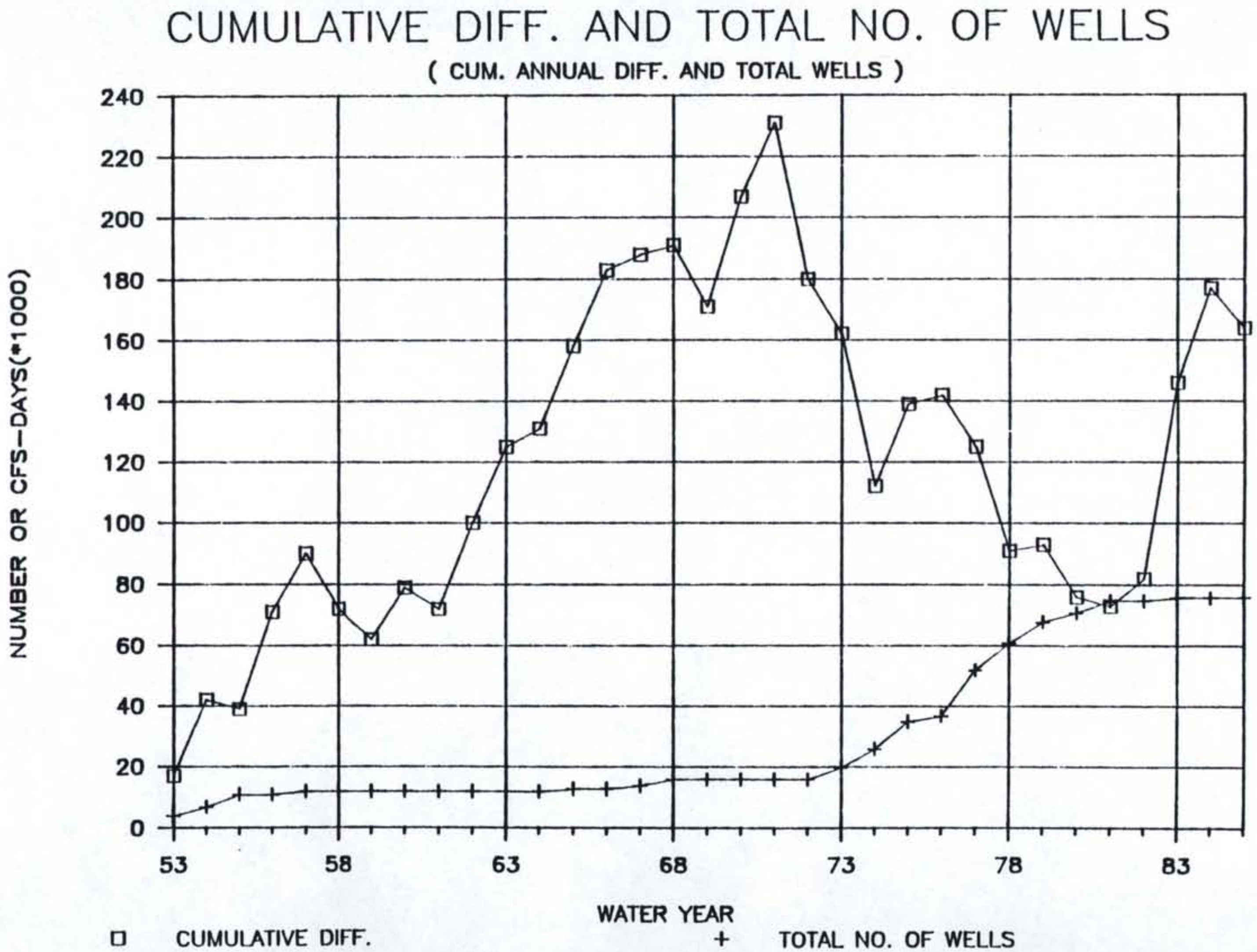

CUMULATIVE DIFF. AND TOTAL NO. OF WELLS
(WINTER SEASON)
NUMBER OR CFS-DAYS(*1000)
80
70
60
50
40
30
20
10
0
53
58
63
68
73
78
83
WATER YEAR
CUMULATIVE DIFF.
+ TOTAL NO. OF WELLS

Fig. 7.7


CUMULATIVE DIFF. AND TOTAL NO. OF WELLS
(CUM. ANNUAL DIFF. AND TOTAL WELLS)
NUMBER OR CFS-DAYS(*1000)
240
220
200
180
160
140
120
100
80
60
40
20
0
53
58
63
68
73
78
83
WATER YEAR
□ CUMULATIVE DIFF.
+ TOTAL NO. OF WELLS

3. Conclusions

From the above results for conjunctive use relationships the following conclusions can be summarized.

1. Although the model appeared to work well, it is not sensitive enough to detect the quantitative effects of the pumping on the surface water flow.
2. Pumped groundwater from deep aquifers mainly in the summer season apparently contributes to streamflows in the fall season as irrigation return flows.
3. No relationship is seen between annual well development and annual change in the streamflows.
4. The historical pattern of groundwater development has paralleled the pattern of streamflow increases in the fall season, and, to a lesser extent, streamflow increases in the summer season.
5. No apparent relationship exists between the observed annual flows and the annual differences.
6. A lack of quantitative data exists concerning the number of irrigation wells pumped, the acreage brought under irrigation, and the water balances for the years 1953 through 1985.

From the comparisons of the observed and synthetic records of the previous chapter and the examinations of the conjunctive use relationships of this chapter, a summary of the results is provided.

As shown in Table 7.2, spring season shows a consistency in results. Although the summer season does not significantly increase streamflows, the season has at least a visual trend of increase in streamflows. For the fall season, the monthly comparison between the synthetic and observed time series shows the synthetic streamflows of August and September were not significantly lower than the observed streamflows. However, the test statistics (Table 6.2) of the two months are very close to the critical values of the significance test on the means. Therefore, it is concluded that the fall season also showed consistent results. Although the synthetic streamflows of two months in the winter season (November, January) are significantly lower than the observed streamflows, the overall synthetic winter streamflows are not significantly lower than the observed winter streamflows. However, since January of the 1965 water year can be treated as an outlier, and the results of the significance test for the January time series would not be accepted. Therefore, it is concluded that the winter season also shows a consistency in results.

Table 7.2

Summary of Tests and Comparisons

Month	Syn.<Obs.	Season	Syn.<Obs.	Pattern Cum. Diff.=Well Dev.	Trend of Cumulative Diff is Significant
Feb	No				
Mar	No	Spring	No	No	No
Apr	No				
May	No				
Jun	No	Summer	No	Yes	Yes
Jul	Yes				
Aug	No				
Sep	No	Fall	Yes	Yes	Yes
Oct	Yes				
Nov	Yes				
Dec	No	Winter	No	No	No
Jan	Yes				

CHAPTER 8

FUTURE IMPACTS AND RECOMMENDED RESEARCH

1. Future Impacts

From the results in Chapters 6 and 7 , it is concluded that the future irrigation well development in this particular basin (with the assumption that the wells have pumped from confined aquifers) will not deplete the nearby streamflows. Rather, pumped groundwater for irrigation purpose from confined aquifers will contribute to streamflows as return flows. More specifically, the irrigation return flows pumped in the summer season may be contributing to the streamflows in the fall season. However, because this increment of the streamflow in the fall season is small in quantity when compared with the other seasons, it may not significantly increase the annual streamflows.

2. Recommended Research

Additional research is recommended for other river basins to investigate the impacts of groundwater withdrawals on surface streamflows by similar modeling procedures. Groundwater pumpage for irrigation of the Raft River Valley in Southern Idaho (Fig.8.1) has decreased the flows of Raft River (51). The confined and unconfined sedimentary aquifers were developed for irrigation primarily in the 1950's and 1960's. The basin was declared critical in 1963 and closed for additional ground water permits. The impacts of development include some indication of land subsidence and a change in surface water flow patterns (51). The Mountain Home Area (Fig.8.1) has also undergone major groundwater development (mostly irrigation purposes) affecting the nearby Canyon Creek in recent years. The aquifers are primarily composed of basalt and have been developed almost exclusively for irrigation. A portion of the area was declared critical in 1981. The entire Mountain Home Area was designated as a groundwater management area in 1982 (51). Therefore, these two basins are recommended to further investigate the impacts of groundwater withdrawals on surface streamflow by the similar multivariate modeling procedures. However, a severe lack of data exists concerning the number of irrigation wells pumped, the acreage brought under irrigation, and the water balances each year for the Camas Creek basin. Therefore, to apply the same multivariate modeling procedures effectively for future studies, sufficient surface and subsurface flow data are necessary.

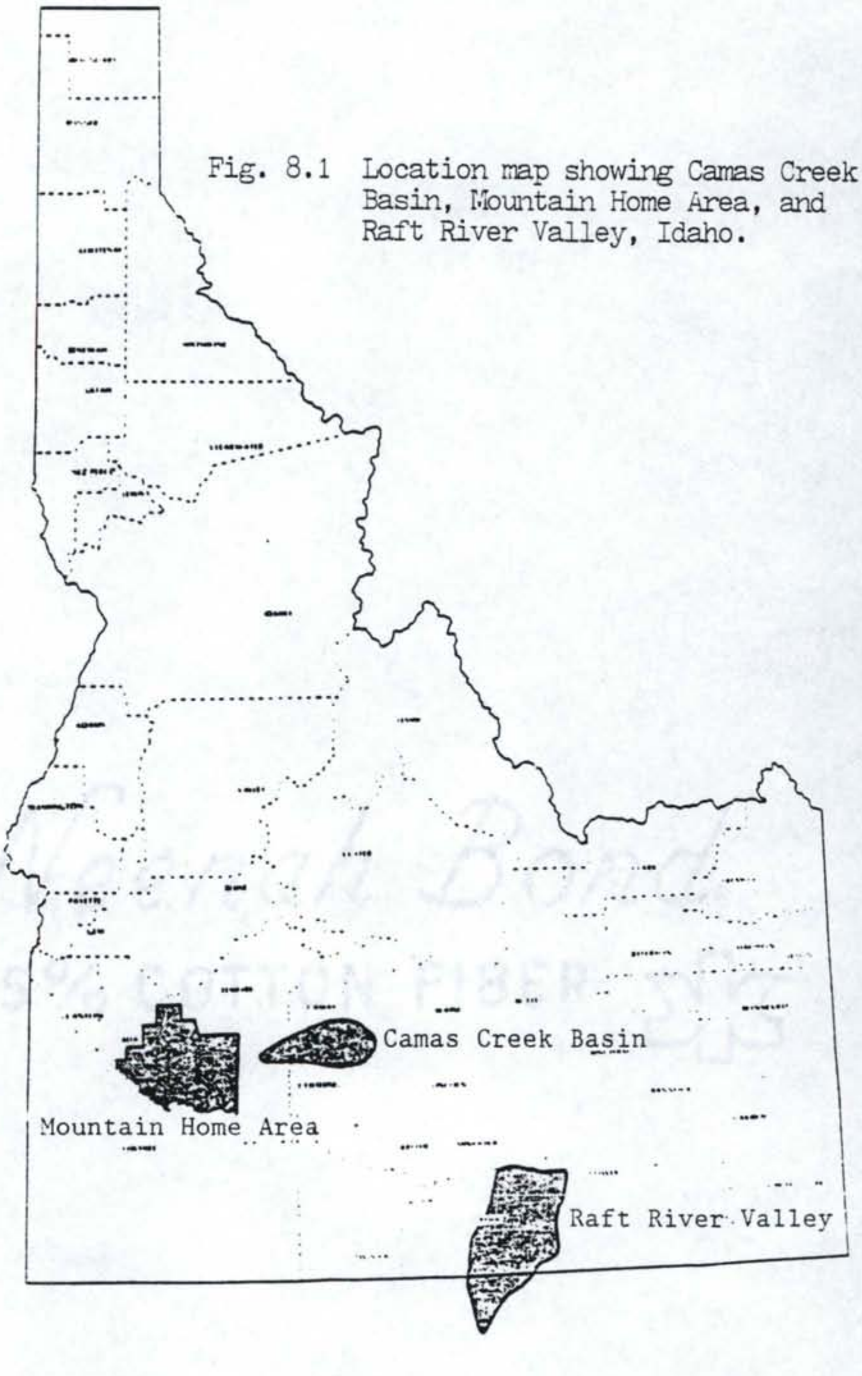


Fig. 8.1 Location map showing Camas Creek Basin, Mountain Home Area, and Raft River Valley, Idaho.

APPENDIX A

CANDIDATE STATIONS

Table A.1

Candidate Stations with at Least
40 years Record, Little Pumping
and/or Regulation, and of at Least
" Fair " Quality

Station Number	Station Name	Area Sq Mi	Record Length	* Remark
13.1415.00	Camas Creek, Blaine	648	1925-1985	G
13.1395.10	Big Wood Slough, Hailey	640	1925-1973	F
13.0825.00	Goose Creek, Oakley	633	1925-1985	G
13.0830.00	Trapper Creek, Oakley	54	1925-1985	G
13.1205.00	Big Lost River, Chilly	450	1925-1985	G
13.1200.00	North Fork ,Chilly	114	1945-1985	G

* E = Excellent; G = Good; F = Fair; P = Poor.

APPENDIX B

HISTORICAL STREAMFLOW LISTINGS

(All units are in cfs-days)

Table B.1

STATION: COMBINATION BIG WOOD R AND SLOUGH AT HAILEY ID (13.1395.10)

WYEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANN
25	4150.00	3945.00	3633.00	3660.00	3456.00	4839.00	23300.00	64960.00	46480.00	26226.00	9979.00	7383.00	202011.00
26	7683.00	5860.00	5540.00	4931.00	4245.00	7482.00	16177.00	18807.00	10420.00	5082.00	3715.00	3398.00	93340.00
27	3732.00	3953.00	3639.00	3817.00	2753.00	4367.00	11976.00	43099.00	68310.00	26097.00	9972.00	7869.00	189584.00
28	7565.00	7656.00	5802.00	4963.00	4361.00	6945.00	11282.00	51737.00	23311.00	11474.00	5214.00	4236.00	144546.00
29	4679.00	4779.00	3763.00	3495.00	3053.00	3948.00	5737.00	16482.00	19343.00	8639.00	4399.00	3835.00	82152.00
30	3631.00	3242.00	4381.00	3218.00	3577.00	5669.00	21565.00	29372.00	30135.00	11617.00	5592.00	4605.00	126604.00
31	6070.00	4655.00	3611.00	3687.00	2937.00	3574.00	6744.00	13539.00	9117.00	3430.00	2441.00	2064.00	61869.00
32	2616.00	2773.00	2948.00	2461.00	2767.00	3335.00	10795.00	39258.00	57327.00	22221.00	7122.00	5702.00	159325.00
33	5236.00	4731.00	4216.00	3967.00	3457.00	3692.00	7640.00	20869.00	41682.00	9905.00	4333.00	3680.00	113408.00
34	3703.00	4194.00	3839.00	3521.00	3560.00	6353.00	11608.00	12906.00	7055.00	3535.00	2322.00	2135.00	64731.00
35	2611.00	3156.00	3064.00	3090.00	3035.00	3614.00	9689.00	30062.00	43760.00	15199.00	5163.00	3917.00	126360.00
36	3826.00	3806.00	3404.00	3554.00	3221.00	3463.00	19515.00	36146.00	27358.00	8051.00	5062.00	3890.00	121296.00
37	3970.00	3301.00	3046.00	3121.00	3167.00	3687.00	7532.00	25962.00	14833.00	7180.00	3632.00	2807.00	82238.00
38	2952.00	3232.00	4202.00	3388.00	3584.00	4339.00	22425.00	75390.00	85100.00	39127.00	11559.00	8271.00	263569.00
39	8863.00	7303.00	6304.00	5590.00	4512.00	8928.00	17818.00	21464.00	11905.00	6968.00	3838.00	3810.00	107303.00
40	4421.00	3859.00	3655.00	3233.00	3239.00	5914.00	18603.00	40634.00	27166.00	8489.00	4402.00	5529.00	129144.00
41	6827.00	5741.00	4591.00	4366.00	4028.00	6527.00	14024.00	39377.00	37747.00	14268.00	9146.00	6770.00	153412.00
42	6178.00	5862.00	6290.00	5416.00	4437.00	4887.00	25789.00	33807.00	46370.00	26557.00	8196.00	5590.00	179379.00
43	5697.00	5798.00	5060.00	4948.00	5032.00	6589.00	42529.00	62940.00	68160.00	49432.00	14262.00	8188.00	278635.00
44	8490.00	7262.00	5524.00	5193.00	4591.00	4939.00	10661.00	30630.00	33998.00	21065.00	7409.00	4793.00	144555.00
45	5549.00	5683.00	4801.00	4673.00	4147.00	4863.00	9471.00	26681.00	34044.00	19819.00	6941.00	5173.00	131845.00
46	4448.00	5108.00	4648.00	4833.00	4335.00	5762.00	29092.00	46060.00	36623.00	15170.00	6634.00	6532.00	169245.00
47	7909.00	6464.00	5164.00	4582.00	4668.00	8575.00	19767.00	45030.00	30174.00	16000.00	6467.00	5123.00	159923.00
48	6268.00	5616.00	4665.00	4445.00	3908.00	4035.00	10417.00	32885.00	50457.00	16853.00	6324.00	4623.00	150496.00
49	5888.00	5054.00	4853.00	5010.00	4023.00	4708.00	18334.00	37982.00	26785.00	9300.00	4578.00	3770.00	130285.00
50	4235.00	4617.00	3964.00	4023.00	3617.00	4044.00	12976.00	34063.00	42140.00	23024.00	8178.00	7000.00	151881.00
51	6864.00	7094.00	5905.00	4960.00	4980.00	5462.00	27952.00	56752.00	44554.00	26772.00	12091.00	7115.00	210501.00
52	8061.00	6187.00	5709.00	5784.00	4988.00	5212.00	29104.00	84650.00	63730.00	27642.00	11358.00	8070.00	260495.00
53	6923.00	5809.00	6177.00	6474.00	4804.00	6541.00	18389.00	24522.00	46396.00	29627.00	9331.00	5599.00	170592.00
54	6261.00	5484.00	4731.00	4949.00	4486.00	5256.00	17562.00	40383.00	27940.00	19824.00	7020.00	4873.00	148769.00
55	5529.00	4887.00	4194.00	4076.00	3560.00	3700.00	4949.00	22147.00	35779.00	15565.00	6493.00	4318.00	115197.00
56	4344.00	4779.00	6776.00	5808.00	4217.00	5853.00	28958.00	72050.00	65070.00	24177.00	9617.00	6744.00	238393.00
57	7557.00	6193.00	5421.00	4706.00	4370.00	5393.00	11061.00	50838.00	58190.00	22243.00	8621.00	5993.00	190586.00
58	6537.00	5776.00	5579.00	5083.00	4612.00	5093.00	12221.00	90720.00	59390.00	21997.00	10287.00	7328.00	234623.00
59	6417.00	6238.00	5691.00	5124.00	4602.00	5091.00	11844.00	16992.00	28884.00	9954.00	4767.00	6880.00	112484.00
60	7491.00	5549.00	4499.00	4372.00	3723.00	5730.00	16726.00	20689.00	23092.00	7193.00	3834.00	3671.00	106569.00
61	4024.00	3827.00	3600.00	3775.00	3308.00	3817.00	7879.00	16352.00	23012.00	6964.00	4528.00	4745.00	85831.00
62	4838.00	4269.00	3590.00	3713.00	3976.00	4298.00	21650.00	29946.00	44461.00	18219.00	8179.00	5800.00	152939.00
63	6914.00	5477.00	4820.00	4196.00	5075.00	5203.00	7311.00	37640.00	48980.00	21480.00	8183.00	6597.00	161876.00
64	6461.00	6430.00	4997.00	4581.00	4401.00	4503.00	12535.00	30527.00	44230.00	22414.00	8218.00	5514.00	154811.00
65	5685.00	5229.00	6716.00	7150.00	5239.00	6577.00	26267.00	64960.00	89140.00	55299.00	21248.00	13367.00	306877.00
66	9744.00	7877.00	6048.00	6198.00	4828.00	5544.00	15408.00	25525.00	17244.00	7559.00	4507.00	3901.00	114383.00
67	4591.00	4738.00	4416.00	4757.00	4009.00	5389.00	9040.00	58421.00	83930.00	37576.00	11305.00	7968.00	236140.00
68	8995.00	7465.00	6234.00	5485.00	4990.00	7165.00	11358.00	16855.00	29887.00	11417.00	9212.00	7332.00	126395.00
69	6949.00	5973.00	4986.00	5169.00	4662.00	5383.00	39887.00	94200.00	60842.00	23445.00	10043.00	7671.00	269210.00
70	7942.00	5956.00	5377.00	5308.00	4342.00	5689.00	8853.00	34402.00	50240.00	26140.00	8866.00	7543.00	170658.00
71	7720.00	7890.00	6454.00	6019.00	6053.00	6541.00	16184.00	67210.00	78570.00	36139.00	12812.00	9977.00	261569.00
72	10156.00	7899.00	6235.00	6627.00	6089.00	10385.00	13215.00	39171.00	76590.00	20869.00	10238.00	8010.00	215484.00
73	8575.00	6886.00	5089.00	5073.00	4604.00	4978.00	9945.00	26786.00	22479.00	10405.00	5639.00	4886.00	115345.00

Table B.2

STATION: BIG LOST RIVER AT HOWELL RANCH NR CHILLY ID (13.1205.00)

WYEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANN
25	2575	.	.	.	.	.	6467	35033	34385	20155	7291	4660	.
26	4198	.	.	.	.	.	.	15422	9770	4936	2526	1887	.
27	2125	.	.	.	.	.	2689	17089	49278	19966	6960	4843	.
28	4720	.	.	.	.	.	4992	35540	18206	10676	4589	2861	.
29	2895	.	.	.	.	.	.	12714	21080	8723	3664	2727	.
30	2309	.	.	.	.	.	8875	21005	28728	10508	6425	3958	.
31	5115	.	.	.	.	.	.	13738	11752	3222	2215	1618	.
32	1964	.	.	.	.	.	2699	23355	42635	17617	5144	3376	.
33	3358	2462	.	.	.	.	2603	9231	34794	7555	3019	1880	.
34	1799	.	.	.	.	.	6487	11321	6619	2897	1679	1430	.
35	1915	1867	.	.	.	.	3164	17574	44882	16567	4478	2467	.
36	2559	2471	.	.	.	.	7911	22261	20424	5875	4421	2566	.
37	2169	.	.	.	.	.	1869	17080	12372	6106	2076	1745	.
38	1919	.	.	.	.	.	7681	36399	62820	32032	9258	4992	.
39	6757	.	.	.	.	.	.	18855	12279	7281	2950	2404	.
40	2657	.	.	.	.	.	.	28549	25078	6942	2546	4841	.
41	5156	.	.	.	.	.	.	26156	28365	12788	7087	4241	.
42	4014	3272	.	.	.	.	11844	18023	34829	22819	5732	3215	.
43	3239	3104	.	.	.	.	14543	33589	44582	36243	10308	4754	.
44	4474	3667	.	.	.	.	2901	23363	41438	31069	8458	4759	.
45	4125	3505	.	.	.	.	3272	16472	27204	19435	6549	4209	.
46	3734	3070	.	.	.	.	12035	26570	29114	12874	5486	4443	.
47	5607	3434	.	.	.	.	6801	33496	24769	14502	5341	3431	.
48	3956	2706	.	.	.	.	5279	23678	43161	15668	5121	3533	.
49	3818	3078	2805	2470	2056	2190	7292	27802	21643	8443	3702	2623	87922
50	2897	2424	1826	1761	1425	2100	5046	17768	30777	18622	5881	4221	94748
51	3587	3371	3560	3100	2670	2190	10280	32449	31946	21444	10481	4363	129441
52	4424	3239	3055	2635	2245	2415	9033	42195	44976	21542	8957	3928	148644
53	3306	2673	2720	2835	2300	2488	5144	13473	40653	26747	6325	3507	112171
54	3214	2824	2211	2063	2006	2227	6143	29708	24352	16634	4776	2737	98895
55	2528	2169	1760	1642	1454	1652	1913	11582	31421	15059	4857	2522	78559
56	2403	1952	2823	1990	1602	2212	9323	43554	53520	19544	6467	3426	148816
57	3321	2671	2188	1945	1825	2220	2688	27145	54063	21420	5868	3720	129074
58	4167	3035	2566	2469	2192	2451	3444	52702	42400	17294	7338	4109	144167
59	3402	2853	2308	2068	1822	2015	3665	8637	26788	8123	3552	4594	69827
60	3840	2697	2171	2271	2099	2534	5321	12631	23089	6095	3033	2158	67939
61	2084	1944	1809	1583	1370	1459	2226	13227	24284	4906	3059	3933	61884
62	3055	2435	1782	1683	2127	2378	9322	16533	41116	15890	7196	3147	106664
63	3890	2917	2419	2035	2285	1987	2774	27695	44643	20060	7087	5221	123013
64	4031	3568	2945	2790	2320	2170	4213	21972	38285	21628	6002	3647	113571
65	3055	2529	2906	3416	2474	2608	6934	30733	70440	45609	18170	7380	196254
66	5262	4019	3230	3177	2788	2893	5538	19617	14787	6580	3386	2663	73940
67	2485	2227	2148	2232	2531	2401	2316	37683	69560	40661	9710	5471	179425
68	6226	3857	2893	2653	2199	2709	4499	16989	40272	14271	9120	6289	111977
69	5029	3734	3166	3138	2476	3078	13431	58282	45363	24184	7893	4751	174525
70	4239	3261	2948	2725	3103	2820	3018	26308	52592	23240	6762	4868	135884
71	4025	3196	2818	3110	2359	2453	3621	30514	55406	29124	9998	5168	151792
72	5401	4402	3106	3162	2233	3240	4673	22365	47800	13475	6234	4491	120582
73	4785	3373	2792	2302	2151	2497	3355	23951	26850	10965	5027	4073	92121
74	3073	3466	2600	3931	2270	3043	10536	34510	63100	22270	7847	4086	160732
75	3428	3004	3002	3097	2524	1965	2075	14775	56150	45094	10155	5156	150425
76	4888	3785	3262	2699	2277	2601	6635	34883	30735	15043	8758	8329	123895
77	5108	3476	2615	2284	1908	1801	3506	6185	23789	8236	4190	2781	65879
78	2761	1821	2271	2573	1891	2532	4423	17535	42080	25559	7189	9939	120574
79	5175	3980	3261	2749	2570	3079	4298	26017	20457	7648	5904	3309	88447
80	2759	2451	2176	2184	1914	1885	6206	30024	34944	26300	7780	6662	125285
81	4543	3798	3300	2737	2234	2588	8771	28302	40014	15348	5742	3671	121048
82	3859	3190	3068	2614	2089	2527	5643	32178	51855	36564	12037	6120	161744
83	6014	4183	3461	2655	1799	1882	3369	32464	66340	41148	16375	6753	186443
84	6927	11196	8612	7586	6317	6003	7572	35292	47554	31981	14343	8100	191483
85	5960	5034	4555	3410	2796	3802	8365	20219	18179	7955	4514	11326	96115

Table B.3

STATION: GOOSE CREEK AB TRAPPER CREEK NR OKLEY ID (13.0825.00)

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANN
24-25	696.00	765.00	899.00	961.00	616.00	1981.00	4718.00	4879.00	1976.00	831.00	483.00	666.00	19471
25-26	899.00	1002.00	806.00	713.00	868.00	1925.00	2214.00	995.00	315.60	422.30	296.30	259.70	10715.9
26-27	593.00	822.00	635.00	682.00	2065.00	1530.00	2141.00	4696.00	2076.00	485.00	331.20	317.70	16373.9
27-28	665.00	862.00	480.00	930.00	1015.00	2527.00	2232.00	4375.00	1077.00	325.00	207.00	240.80	14935.8
28-29	529.00	693.00	589.00	558.00	530.00	1318.00	2822.00	5165.00	2190.00	485.10	347.20	398.70	15625
29-30	543.00	622.00	763.00	522.00	1074.00	1147.00	1332.00	1579.00	551.90	205.00	344.40	304.10	8987.40
30-31	590.00	608.00	565.00	545.00	690.00	1435.00	1421.00	720.00	295.50	58.20	96.80	152.60	7177.10
31-32	343.60	455.00	465.00	620.00	670.00	1818.00	2464.00	4988.00	2539.00	665.00	332.90	296.00	15656.5
32-33	476.00	660.00	490.00	558.00	500.00	1351.00	1514.00	3055.00	1934.00	396.20	183.30	185.10	11302.6
33-34	359.40	552.00	620.00	723.00	759.00	1039.00	777.20	413.90	231.10	28.30	10.10	75.90	5588.90
34-35	299.00	465.00	496.00	558.00	560.00	968.00	1472.00	2254.00	892.00	262.50	6.10	0.00	8232.60
35-36	153.90	428.00	487.00	558.00	580.00	979.00	3462.00	4037.00	1313.20	265.60	500.20	233.10	12997
36-37	442.30	577.00	527.00	496.00	560.00	1399.00	1800.00	3223.00	1071.70	354.50	105.60	79.90	10636
37-38	247.20	575.00	798.00	775.00	875.00	1336.00	2866.00	5098.00	1452.00	684.00	190.20	245.50	15141.9
38-39	388.20	662.00	744.00	713.00	616.00	4755.00	3336.00	1483.00	285.40	100.00	54.40	26.70	13163.7
39-40	299.40	443.00	542.00	775.00	750.00	1155.00	1895.00	1011.90	268.40	19.60	0.00	27.10	7186.40
40-41	213.30	378.00	446.00	558.00	801.00	1123.00	1853.00	2126.00	953.80	392.00	420.40	306.30	9570.80
41-42	497.00	737.00	813.00	713.00	672.00	2473.00	5822.00	7640.00	3646.00	686.00	209.10	170.50	24078.6
42-43	360.30	710.00	1005.00	2460.00	3115.00	2140.00	5333.00	3544.00	2848.00	615.00	244.20	152.40	22526.9
43-44	395.60	645.00	659.00	572.00	645.00	1430.00	2562.00	4361.00	2849.00	670.60	274.40	131.50	15195.1
44-45	338.40	558.00	433.00	677.00	1825.00	1547.00	2204.00	5576.00	2701.00	675.00	370.50	332.10	17237
45-46	528.00	835.00	1049.00	994.00	1096.00	2509.00	5421.00	5342.00	1558.00	479.30	273.40	335.70	20420.4
46-47	665.00	825.00	866.00	571.00	1365.00	1673.00	2025.00	1730.00	759.00	186.50	121.70	93.40	10880.6
47-48	350.50	586.00	731.00	634.00	1144.00	1222.00	2137.00	3577.00	1107.00	306.10	143.10	116.90	12054.6
48-49	280.90	513.00	574.00	497.00	445.00	2014.00	4900.00	6714.00	1875.00	327.30	195.70	185.80	18521.7
49-50	568.00	668.00	492.00	569.00	794.00	1419.00	3004.00	4764.00	2122.00	500.00	379.60	229.50	15509.1
50-51	509.00	721.00	965.00	767.00	4019.00	2695.00	4978.00	6696.00	1859.00	413.40	539.00	268.80	24430.2
51-52	550.00	615.00	568.00	566.00	624.00	1361.00	5501.00	9223.00	2589.00	872.00	685.00	398.00	23552
52-53	559.00	631.00	694.00	1173.00	924.00	1340.00	2505.00	4004.00	3208.00	674.00	651.60	327.60	16691.2
53-54	518.00	669.00	639.00	694.00	926.00	1286.00	1596.00	857.50	334.00	132.50	83.00	162.40	7897.40
54-55	439.00	583.00	491.50	512.00	556.00	1050.00	1190.00	1957.00	782.00	437.30	286.40	173.80	8458.00
55-56	426.00	625.00	997.00	1370.00	756.00	3368.00	3700.00	4050.00	925.90	224.50	163.20	120.60	16726.2
56-57	422.50	589.00	834.30	559.00	1782.00	1791.00	2283.00	6604.00	2310.00	398.70	254.40	211.10	18039
57-58	490.30	678.00	749.00	719.00	3232.00	1777.00	3300.00	7110.00	1873.00	492.00	390.20	257.50	21068
58-59	475.00	675.00	827.00	853.00	914.00	1134.00	1759.00	1073.00	493.60	240.30	133.90	278.70	8856.50
59-60	626.00	565.00	467.00	502.00	604.00	1778.00	2235.00	1544.00	350.80	175.50	135.70	173.50	9156.50
60-61	413.90	633.00	546.00	597.00	996.00	1261.00	1433.00	686.00	430.40	150.10	359.30	463.50	7969.20
61-62	521.00	626.00	688.00	2128.00	6749.00	3785.00	3842.00	2957.00	1778.00	402.00	373.10	230.80	24079.9
62-63	429.00	596.00	583.00	353.60	1084.00	1098.00	1285.00	2507.00	2294.00	470.80	202.50	341.80	11244.7
63-64	400.00	687.00	440.70	458.00	555.00	1364.00	2464.00	4685.00	3831.00	877.00	355.50	314.00	16431.2
64-65	440.40	672.00	1403.00	2435.00	2024.00	1387.00	3881.00	5673.00	2290.00	700.00	594.00	507.00	22006.4
65-66	633.00	742.60	632.20	687.00	736.00	1736.00	2076.00	811.90	254.00	61.70	42.32	41.80	8454.52
66-67	329.20	525.00	425.50	678.00	779.00	1051.00	1190.00	2348.00	2249.00	761.00	299.70	238.10	10873.5
67-68	426.60	457.00	366.60	471.00	1522.00	1507.00	1448.00	1052.00	444.90	163.80	469.90	396.00	8724.80
68-69	500.00	743.00	749.00	997.00	900.00	2104.00	4878.00	3122.00	833.00	435.00	213.80	212.60	15687.4
69-70	442.90	533.00	592.00	2484.00	1251.00	1120.00	1672.00	6928.00	3506.00	931.00	458.20	420.00	20338.1
70-71	609.00	813.00	942.00	5043.00	1969.00	2434.00	4801.00	9386.00	3604.00	841.00	554.00	409.00	31405
71-72	732.00	944.00	992.00	1412.00	1728.00	4145.00	4764.00	7962.00	3579.00	555.20	441.00	553.00	27807.2
72-73	966.00	1141.00	1172.00	1059.00	1301.00	2116.00	4151.00	7003.00	1560.00	570.80	513.00	585.00	22137.8
73-74	834.00	1087.00	891.00	780.00	1348.00	2941.00	5385.00	7080.00	1929.00	546.00	434.20	331.50	23586.7
74-75	668.00	869.00	704.00	902.50	1477.00	3096.00	2092.00	9428.00	9949.00	2087.00	966.00	653.00	32891.5
75-76	1052.00	1133.00	1308.00	915.00	1885.00	2972.00	4252.00	7283.00	1505.00	477.00	699.00	663.00	24144
76-77	889.00	946.00	863.00	847.00	902.00	1292.00	1327.00	1273.00	774.40	284.70	319.40	381.10	10098.6
77-78	563.00	703.00	932.00	1041.00	1012.00	1967.00	4055.00	5043.00	1524.00	368.20	326.60	613.00	18147.8
78-79	624.00	700.00	722.00	693.00	1989.00	3976.00	2717.00	5044.00	1447.00	364.50	476.70	402.00	19155.2
79-80	532.00	716.00	772.00	2761.00	2174.00	1389.00	3263.00	5718.00	3927.00	974.00	540.00	544.00	23310
80-81	698.00	847.00	981.00	857.00	901.00	1242.00	1670.00	1138.00	278.60	44.60	51.00	72.10	8780.30
82-83	860.00	955.00	920.00	897.00	1301.00	2329.00	3334.00	8184.00	4848.00	1230.00	993.00	671.00	26522
83-84	903.00	1003.00	1165.00	1244.00	1195.00	2927.00	5533.00	19379	9457.00	2614.00	1641.00	1186.00	48247
84-85	1416.00	1527.00	1084.00	1018.00	1057.00	2419.00	4625.00	3641.00	967.00	695.00	552.00	657.00	19658

Table B.4

STATION: CAMAS CREEK NR BLAINE ID (13.1415.00)

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANN
24-25	.	.	.	.	.	.	.	.	3225.00	549.00	186.60	167.10	.
25-26	.	.	.	.	.	.	5947.00	1137.00	167.40	86.60	66.50	82.90	.
26-27	.	.	.	.	.	.	56009	26431	8658.00	1224.00	177.90	177.40	.
27-28	.	.	.	.	.	.	9170.00	5594.00	1020.00	279.20	122.10	98.00	.
28-29	.	.	.	.	.	.	15617	5860.00	636.70	99.50	76.90	87.80	.
29-30	.	.	.	.	.	.	6443.00	5301.00	1359.20	123.00	70.10	77.90	.
30-31	.	.	.	.	.	.	4729.00	963.80	97.20	55.80	54.50	65.40	.
31-32	.	.	.	.	.	.	30250	13658	8729.00	695.20	97.90	85.00	.
32-33	.	.	.	.	.	.	.	13362	3609.00	192.40	69.40	85.10	.
33-34	.	.	.	.	.	.	1969.00	373.40	89.60	61.80	55.80	73.20	.
34-35	.	.	.	.	.	.	20777	4771.00	2250.10	104.70	61.70	55.20	.
35-36	77.80	.	.	.	.	.	44438	12923	3311.20	122.60	96.10	74.40	.
36-37	107.50	.	.	.	.	.	21975	5618.00	848.60	99.80	56.60	58.90	.
37-38	94.40	130.60	.	.	.	.	73994	27287	6637.00	1942.00	166.60	144.60	.
38-39	366.90	.	.	.	.	.	14990	3126.00	347.50	122.50	70.30	61.80	.
39-40	.	.	.	.	.	.	17494	5445.00	848.40	72.10	56.00	291.90	.
40-41	.	.	.	.	.	7086.00	15155	6839.00	2813.00	313.10	148.10	159.90	.
41-42	.	.	.	.	.	.	.	11174	4403.00	415.80	96.00	88.90	.
42-43	.	.	.	.	.	.	106560	20442	9315.00	2295.00	265.40	226.50	.
43-44	415.60	672.00	.	.	.	.	13843	6109.00	4176.00	583.40	136.70	120.80	.
44-45	176.80	363.40	276.00	705.00	1641.00	6829.00	21292	6293.00	3598.00	511.90	125.00	113.90	41925
45-46	195.80	320.80	374.00	392.00	349.00	2475.00	64735	13213	3350.00	388.90	128.90	133.80	86056.2
46-47	432.70	702.00	1754.00	620.00	5614.00	14289	7158.00	4570.00	1813.00	233.80	100.70	100.10	37387.3
47-48	149.20	284.00	336.40	316.00	1552.00	2804.00	14875	6736.00	2652.00	222.10	91.30	105.70	30123.7
48-49	139.00	295.90	310.00	310.00	358.00	1827.00	36563	9255.00	2044.00	199.40	91.00	95.90	51488.2
49-50	149.20	275.60	254.30	364.00	406.00	2236.00	52032	19078	6318.00	1214.80	299.70	253.70	82881.3
50-51	380.20	865.00	1130.00	775.00	1325.00	2346.00	56943	19993	4846.00	901.80	459.80	155.70	90120.5
51-52	425.40	689.00	881.00	775.00	702.00	875.00	99367	43597	9166.00	2641.00	502.00	312.60	159933
52-53	400.00	744.00	776.00	1313.00	1971.00	11714	28167	9567.00	6295.00	811.90	207.10	138.00	62104
53-54	229.70	388.60	665.00	594.00	903.00	5191.00	24905	7307.00	1674.00	642.20	133.90	111.60	42745
54-55	181.00	330.40	351.30	411.00	383.00	717.00	6285.00	7043.00	2204.00	322.70	104.60	91.00	18424
55-56	141.50	252.30	2058.20	3076.00	1938.00	5700.00	65176	18306	5624.00	488.50	148.90	116.50	103026
56-57	294.80	441.00	1760.00	558.00	6734.00	27548	22824	17283	6056.00	541.20	151.80	123.30	84315.1
57-58	245.10	336.00	445.00	618.00	918.00	2899.00	40878	26334	7644.00	849.80	159.90	202.70	81529.5
58-59	312.70	402.50	848.00	747.00	772.00	2905.00	15358	4262.00	603.00	148.50	96.20	321.60	26776.5
59-60	285.30	307.40	394.00	467.00	875.00	1370.00	34326	7528.00	1109.90	169.70	85.20	101.20	47018.7
60-61	139.90	232.50	300.80	290.30	1492.00	5548.00	6719.00	881.00	376.10	56.50	59.00	92.80	16187.9
61-62	142.90	163.90	269.20	634.00	2664.00	1447.00	48477	13963	7328.00	771.00	167.40	97.60	76125
62-63	245.50	389.30	680.00	509.00	31283	2423.00	4479.00	7764.00	6720.00	980.70	107.60	163.50	55744.6
63-64	256.50	625.00	589.00	527.00	580.00	866.00	27849	9858.00	4873.00	483.50	146.70	103.90	46757.6
64-65	238.00	385.00	13990	7640.00	8377.00	18172	56662	25534	13012	3937.00	1224.00	957.00	150128
65-66	1251.00	1535.00	1273.00	1288.00	1132.00	8066.00	23562	5011.00	1130.00	176.80	98.30	101.60	44624.7
66-67	173.10	398.10	408.00	674.00	792.00	3352.00	14826	14917	10449	2027.70	172.70	204.50	48394.1
67-68	338.00	538.00	499.00	569.00	1467.00	7907.00	3667.00	1455.00	2722.00	233.50	152.70	191.70	19739.9
68-69	255.90	467.90	459.00	916.00	1033.00	1486.00	83176	23195	6306.00	1496.70	180.50	226.00	119198
69-70	403.70	602.00	674.00	794.00	1043.00	7639.00	30808	14652	6785.00	1857.00	218.40	241.60	65717.7
70-71	477.10	1560.00	1769.00	1841.00	6389.00	16194	82010	32282	11911	2824.00	599.00	367.90	158224
71-72	846.00	1328.00	1223.00	1160.00	1251.00	43370	24666	15668	7904.00	1045.40	336.00	297.80	99095.2
72-73	703.00	1052.00	926.00	1017.00	1020.00	2497.00	22473	5906.00	1012.00	228.90	138.10	132.40	37105.4
73-74	207.00	969.00	959.00	1003.00	1159.00	29946	40739	15388	5046.00	584.40	149.10	128.00	96277.5
74-75	272.60	590.00	620.00	617.00	776.00	1668.00	23006	45552	8573.00	2876.00	264.60	285.40	85100.6
75-76	406.40	789.00	1143.00	845.00	925.00	1415.00	40671	10568	1809.00	267.80	214.90	279.10	59333.2
76-77	387.00	461.00	478.00	473.00	623.00	959.00	569.40	422.10	170.20	120.20	79.10	76.40	4818.40
77-78	96.50	200.30	596.90	521.00	660.00	8629.00	42615	15053	5660.00	1742.90	69.70	220.70	76065
78-79	253.10	331.80	422.00	363.60	560.00	8141.00	6212.00	3873.00	368.20	111.90	79.00	76.80	20792.4
79-80	178.20	257.70	273.00	439.80	1094.40	5077.00	21374	14834	6560.00	1431.90	139.10	154.80	51813.9
80-81	325.20	447.00	787.00	834.00	1615.00	5804.00	5242.00	4224.00	2101.00	100.40	65.90	62.30	21607.8
81-82	137.30	371.20	811.00	650.00	1190.00	7823.00	62423	31912	10919	2663.00	218.00	382.00	119499
82-83	613.00	1039.00	968.00	1175.00	1298.00	23302	62200	48124	18642	5102.00	858.00	495.00	163816
83-84	1230.00	2480.00	1618.00	2032.00	2525.00	5516.00	65561	32049	12798	2418.00	639.00	468.00	129334
84-85	880.00	1595.00	1147.00	1114.00	1057.00	1572.00	34725	8198	1603	190.2	157.9	322.60	52561.7

APPENDIX C

PARAMETERS FOR SIMPLE LINEAR REGRESSION

Table C.1

Statistics for Simple Linear Regression
Between 13.1395.10 & 13.1395.00

Period	α	β	R-square
October	1066.672420	0.904578	0.9910
November	1148.160003	0.873004	0.9871
December	1150.033244	0.844915	0.9575
January	1297.324493	0.806571	0.9432
Feburary	1288.587721	0.777823	0.9467
March	887.802124	0.903382	0.9740
April	542.092765	0.997925	0.9987
May	656.222229	0.996444	0.9996
June	345.010716	1.005019	0.9998
July	577.370228	0.998423	0.9996
August	458.899556	0.996036	0.9971
September	586.534051	0.966631	0.9955

APPENDIX D

AUGMENTED STREAMFLOW LISTINGS AND STATISTICS

(All units are in cfs-days)

Table D.1

STATION: COMBINATION BIG WOOD R AND SLOUGH AT HAILEY ID (13.1395.10)

WYEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANN
25	4150.00	3945.00	3633.00	3660.00	3456.00	4839.00	23300.00	64960.00	46480.00	26226.00	9979.00	7383.00	202011
26	7683.00	5860.00	5540.00	4931.00	4245.00	7482.00	16177.00	18807.00	10420.00	5082.00	3715.00	3398.00	93340
27	3732.00	3953.00	3639.00	3817.00	2753.00	4367.00	11976.00	43099.00	68310.00	26097.00	9972.00	7869.00	189584
28	7565.00	7656.00	5802.00	4963.00	4361.00	6945.00	11282.00	51737.00	23311.00	11474.00	5214.00	4236.00	144546
29	4679.00	4779.00	3763.00	3495.00	3053.00	3948.00	5737.00	16482.00	19343.00	8639.00	4399.00	3835.00	82152
30	3631.00	3242.00	4381.00	3218.00	3577.00	5669.00	21565.00	29372.00	30135.00	11617.00	5592.00	4605.00	126604
31	6070.00	4655.00	3611.00	3687.00	2937.00	3574.00	6744.00	13539.00	9117.00	3430.00	2441.00	2064.00	61869
32	2616.00	2773.00	2948.00	2461.00	2767.00	3335.00	10795.00	39258.00	57327.00	22221.00	7122.00	5702.00	159325
33	5236.00	4731.00	4216.00	3967.00	3457.00	3692.00	7640.00	20869.00	41682.00	9905.00	4333.00	3680.00	113408
34	3703.00	4194.00	3839.00	3521.00	3560.00	6353.00	11608.00	12906.00	7055.00	3535.00	2322.00	2135.00	64731
35	2611.00	3156.00	3064.00	3090.00	3035.00	3614.00	9689.00	30062.00	43760.00	15199.00	5163.00	3917.00	126360
36	3826.00	3806.00	3404.00	3554.00	3221.00	3463.00	19515.00	36146.00	27358.00	8051.00	5062.00	3890.00	121296
37	3970.00	3301.00	3046.00	3121.00	3167.00	3687.00	7532.00	25962.00	14833.00	7180.00	3632.00	2807.00	82238
38	2952.00	3232.00	4202.00	3388.00	3584.00	4339.00	22425.00	75390.00	85100.00	39127.00	11559.00	8271.00	263569
39	8863.00	7303.00	6304.00	5590.00	4512.00	8928.00	17818.00	21464.00	11905.00	6968.00	3838.00	3810.00	107303
40	4421.00	3859.00	3655.00	3233.00	3239.00	5914.00	18603.00	40634.00	27166.00	8489.00	4402.00	5529.00	129144
41	6827.00	5741.00	4591.00	4366.00	4028.00	6527.00	14024.00	39377.00	37747.00	14268.00	9146.00	6770.00	153412
42	6178.00	5862.00	6290.00	5416.00	4437.00	4887.00	25789.00	33807.00	46370.00	26557.00	8196.00	5590.00	179379
43	5697.00	5798.00	5060.00	4948.00	5032.00	6589.00	42529.00	62940.00	68160.00	49432.00	14262.00	8188.00	278635
44	8490.00	7262.00	5524.00	5193.00	4591.00	4939.00	10661.00	30630.00	33998.00	21065.00	7409.00	4793.00	144555
45	5549.00	5683.00	4801.00	4673.00	4147.00	4863.00	9471.00	26681.00	34044.00	19819.00	6941.00	5173.00	131845
46	4448.00	5108.00	4648.00	4833.00	4335.00	5762.00	29092.00	46060.00	36623.00	15170.00	6634.00	6532.00	169245
47	7909.00	6464.00	5164.00	4582.00	4668.00	8575.00	19767.00	45030.00	30174.00	16000.00	6467.00	5123.00	159923
48	6268.00	5616.00	4665.00	4445.00	3908.00	4035.00	10417.00	32885.00	50457.00	16853.00	6324.00	4623.00	150496
49	5888.00	5054.00	4853.00	5010.00	4023.00	4708.00	18334.00	37982.00	26785.00	9300.00	4578.00	3770.00	130285
50	4235.00	4617.00	3964.00	4023.00	3617.00	4044.00	12976.00	34063.00	42140.00	23024.00	8178.00	7000.00	151881
51	6864.00	7094.00	5905.00	4960.00	4980.00	5462.00	27952.00	56752.00	44554.00	26772.00	12091.00	7115.00	210501
52	8061.00	6187.00	5709.00	5784.00	4988.00	5212.00	29104.00	84650.00	63730.00	27642.00	11358.00	8070.00	260495
53	6923.00	5809.00	6177.00	6474.00	4804.00	6541.00	18389.00	24522.00	46396.00	29627.00	9331.00	5599.00	170592
54	6261.00	5484.00	4731.00	4949.00	4486.00	5256.00	17562.00	40383.00	27940.00	19824.00	7020.00	4873.00	148769
55	5529.00	4887.00	4194.00	4076.00	3560.00	3700.00	4949.00	22147.00	35779.00	15565.00	6493.00	4318.00	115197
56	4344.00	4779.00	6776.00	5808.00	4217.00	5853.00	28958.00	72050.00	65070.00	24177.00	9617.00	6744.00	238393
57	7557.00	6193.00	5421.00	4706.00	4370.00	5393.00	11061.00	50838.00	58190.00	22243.00	8621.00	5993.00	190586
58	6537.00	5776.00	5579.00	5083.00	4612.00	5093.00	12221.00	90720.00	59390.00	21997.00	10287.00	7328.00	234623
59	6417.00	6238.00	5691.00	5124.00	4602.00	5091.00	11844.00	16992.00	28884.00	9954.00	4767.00	6880.00	112484
60	7491.00	5549.00	4499.00	4372.00	3723.00	5730.00	16726.00	20689.00	23092.00	7193.00	3834.00	3671.00	106569
61	4024.00	3827.00	3600.00	3775.00	3308.00	3817.00	7879.00	16352.00	23012.00	6964.00	4528.00	4745.00	85831
62	4838.00	4269.00	3590.00	3713.00	3976.00	4298.00	21650.00	29946.00	44461.00	18219.00	8179.00	5800.00	152939
63	6914.00	5477.00	4820.00	4196.00	5075.00	5203.00	7311.00	37640.00	48980.00	21480.00	8183.00	6597.00	161876
64	6461.00	6430.00	4997.00	4581.00	4401.00	4503.00	12535.00	30527.00	44230.00	22414.00	8218.00	5514.00	154811
65	5685.00	5229.00	6716.00	7150.00	5239.00	6577.00	26267.00	64960.00	89140.00	55299.00	21248.00	13367.00	306877
66	9744.00	7877.00	6048.00	6198.00	4828.00	5544.00	15408.00	25525.00	17244.00	7559.00	4507.00	3901.00	114383
67	4591.00	4738.00	4416.00	4757.00	4009.00	5389.00	9040.00	58421.00	83930.00	37576.00	11305.00	7968.00	236140
68	8995.00	7465.00	6234.00	5485.00	4990.00	7165.00	11358.00	16855.00	29887.00	11417.00	9212.00	7332.00	126395
69	6949.00	5973.00	4986.00	5169.00	4662.00	5383.00	39887.00	94200.00	60842.00	23445.00	10043.00	7671.00	269210
70	7942.00	5956.00	5377.00	5308.00	4342.00	5689.00	8853.00	34402.00	50240.00	26140.00	8866.00	7543.00	170658
71	7720.00	7890.00	6454.00	6019.00	6053.00	6541.00	16184.00	67210.00	78570.00	36139.00	12812.00	9977.00	261569
72	10156.00	7899.00	6235.00	6627.00	6089.00	10385.00	13215.00	39171.00	76590.00	20869.00	10238.00	8010.00	215484
73	8575.00	6886.00	5089.00	5073.00	4604.00	4978.00	9945.00	26786.00	22479.00	10405.00	5639.00	4886.00	115345
74	-6010.28	-6820.46	-5739.06	-6108.39	-5158.13	-8997.40	-33506.87	-69091.55	-96055.35	-30369.39	-12391.63	-7906.38	-288154
75	-7938.55	-7011.88	-5664.87	-5533.86	-4743.91	-5454.02	-6854.19	-34155.35	-67545.67	-47571.76	-12600.81	-7933.37	-213008
76	-8140.92	-7168.31	-6321.85	-5701.01	-5267.30	-5770.25	-15087.68	-46322.41	-33758.23	-16364.10	-11120.94	-9539.45	-170562
77	-7923.47	-6107.50	-5344.28	-5120.43	-4347.78	-4897.15	-5379.55	-7333.32	-18006.78	-8594.22	-5399.71	-4837.99	-83292
78	-5165.32	-4604.08	-4643.38	-4513.59	-4090.43	-6346.44	-19098.34	-41236.07	-54000.18	-30044.70	-11082.96	-10564.87	-195390
79	-7203.08	-6019.22	-4984.62	-4805.35	-4192.72	-5164.08	-8865.90	-28121.71	-20469.58	-8873.64	-6486.50	-4757.55	-109943
80	-5303.95	-4796.99	-4576.83	-4912.05	-4478.85	-5169.93	-19730.70	-53929.87	-50420.17	-33029.52	-11652.93	-9567.12	-207568
81	-8381.32	-6827.05	-6104.47	-5818.46	-5061.64	-7023.70	-17668.14	-37822.64	-41263.99	-14581.37	-6876.95	-5052.00	-162431
82	-6795.34	-6288.24	-5391.64	-5166.99	-4888.13	-7041.85	-15415.81	-74780.02	-87248.77	-44821.85	-15986.58	-10110.40	-283935
83	-9312.85	-7619.31	-6575.48	-6210.31	-5316.14	-8114.26	-14808.50	-67566.52	-98468.14	-48130.97	-21177.28	-12672.75	-305972
84	-13048.78	-12423.81	-9637.41	-8533.27	-7509.15	-8969.02	-19743.43	-54876.18	-60210.94	-35020.37	-14948.61	-10125.68	-255046
85	-9314.88	-8213.21	-7391.99	-7133.91	-5716.75	-7316.81	-22425.58	-32410.60	-23522.14	-11247.82	-7631.43	-11988.15	-154313

* " - " INDICATE ESTIMATED FLOWS

Table D.2

STATION: BIG LOST RIVER AT HOWELL RANCH NR CHILLY ID (13.1205.00)

WYEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANN
25	2575	-2005.58	-1768.32	-1743.96	-1557.81	-1877.46	6467.00	35033	34385	20155	7291	4660	-119519.13
26	4198	-3468.12	-3063.64	-2774.35	-2131.84	-2903.15	-6281.21	15422	9770	4936	2526	1887	-59361.31
27	2125	-2595.73	-2378.42	-2329.69	-1997.44	-2305.50	2689.00	17089	49278	19966	6960	4843	-114556.78
28	4720	-3902.47	-2885.19	-2538.33	-1941.37	-2667.61	4992.00	35540	18206	10676	4589	2861	-95518.97
29	2895	-2329.53	-1713.21	-1576.82	-1319.89	-1578.24	-1524.86	12714	21080	8723	3664	2727	-61845.55
30	2309	-2211.28	-2424.99	-1928.57	-1794.94	-2337.67	8875.00	21005	28728	10508	6425	3958	-92505.45
31	5115	-3219.20	-2527.90	-2414.68	-2012.80	-2184.65	-2759.75	13738	11752	3222	2215	1618	-52778.98
32	1964	-1937.93	-1842.10	-1571.24	-1637.90	-1671.61	2699.00	23355	42635	17617	5144	3376	-105450.78
33	3358	2462.00	-2542.46	-2355.97	-2014.82	-2030.20	2603.00	9231	34794	7555	3019	1880	-73845.45
34	1799	-3135.02	-2744.19	-2485.65	-2281.88	-2896.75	6487.00	11321	6619	2897	1679	1430	-45775.49
35	1915	1867.00	-2549.20	-2394.46	-2272.53	-2310.30	3164.00	17574	44882	16567	4478	2467	-102440.49
36	2559	2471.00	-2522.16	-2434.87	-2179.10	-2143.24	7911.00	22261	20424	5875	4421	2566	-77767.37
37	2169	-2771.67	-2446.69	-2305.23	-2265.48	-2314.36	1869.00	17080	12372	6106	2076	1745	-55520.43
38	1919	-2112.95	-2377.82	-2002.50	-1991.11	-2144.75	7681.00	36399	62820	32032	9258	4992	-165730.13
39	6757	-3841.80	-3140.93	-2842.50	-2076.02	-3002.11	-6592.87	18855	12279	7281	2950	2404	-72022.23
40	2657	-2449.66	-2216.07	-1972.40	-1930.27	-2516.20	-6681.44	28549	25078	6942	2546	4841	-88379.04
41	5156	-3212.73	-2590.82	-2432.46	-2165.50	-2630.28	-5513.01	26156	28365	12788	7087	4241	-102337.80
42	4014	3272.00	-2985.91	-2658.97	-2155.64	-2198.31	11844.00	18023	34829	22819	5732	3215	-113746.83
43	3239	3104.00	-2368.57	-2317.90	-2023.70	-2346.83	14543.00	33589	44582	36243	10308	4754	-159419.00
44	4474	3667.00	-2538.23	-2417.74	-1899.25	-1987.65	2901.00	23363	41438	31069	8458	4759	-128971.87
45	4125	3505.00	-2602.41	-2505.74	-2132.77	-2234.78	3272.00	16472	27204	19435	6549	4209	-94246.70
46	3734	3070.00	-2805.55	-2777.14	-2428.28	-2681.59	12035.00	26570	29114	12874	5486	4443	-108018.56
47	5607	3434.00	-3015.49	-2709.75	-2427.79	-3179.17	6801.00	33496	24769	14502	5341	3431	-108713.20
48	3956	2706.00	-2218.93	-2085.36	-1705.40	-1714.64	5279.00	23678	43161	15668	5121	3533	-110826.33
49	3818	3078.00	2805.00	2470.00	2056.00	2190.00	7292.00	27802	21643	8443	3702	2623	87922.00
50	2897	2424.00	1826.00	1761.00	1425.00	2100.00	5046.00	17768	30777	18622	5881	4221	94748.00
51	3587	3371.00	3560.00	3100.00	2670.00	2190.00	10280.00	32449	31946	21444	10481	4363	129441.00
52	4424	3239.00	3055.00	2635.00	2245.00	2415.00	9033.00	42195	44976	21542	8957	3928	148644.00
53	3306	2673.00	2720.00	2835.00	2300.00	2488.00	5144.00	13473	40653	26747	6325	3507	112171.00
54	3214	2824.00	2211.00	2063.00	2006.00	2227.00	6143.00	29708	24352	16634	4776	2737	98895.00
55	2528	2169.00	1760.00	1642.00	1454.00	1652.00	1913.00	11582	31421	15059	4857	2522	78559.00
56	2403	1952.00	2823.00	1990.00	1602.00	2212.00	9323.00	43554	53520	19544	6467	3426	148816.00
57	3321	2671.00	2188.00	1945.00	1825.00	2220.00	2688.00	27145	54063	21420	5868	3720	129074.00
58	4167	3035.00	2566.00	2469.00	2192.00	2451.00	3444.00	52702	42400	17294	7338	4109	144167.00
59	3402	2853.00	2308.00	2068.00	1822.00	2015.00	3665.00	8637	26788	8123	3552	4594	69827.00
60	3840	2697.00	2171.00	2271.00	2099.00	2534.00	5321.00	12631	23089	6095	3033	2158	67939.00
61	2084	1944.00	1809.00	1583.00	1370.00	1459.00	2226.00	13227	24284	4906	3059	3933	61884.00
62	3055	2435.00	1782.00	1683.00	2127.00	2378.00	9322.00	16533	41116	15890	7196	3147	106664.00
63	3890	2917.00	2419.00	2035.00	2285.00	1987.00	2774.00	27695	44643	20060	7087	5221	123013.00
64	4031	3568.00	2945.00	2790.00	2320.00	2170.00	4213.00	21972	38285	21628	6002	3647	113571.00
65	3055	2529.00	2906.00	3416.00	2474.00	2608.00	6934.00	30733	70440	45609	18170	7380	196254.00
66	5262	4019.00	3230.00	3177.00	2788.00	2893.00	5538.00	19617	14787	6580	3386	2663	73940.00
67	2485	2227.00	2148.00	2232.00	2531.00	2401.00	2316.00	37683	69560	40661	9710	5471	179425.00
68	6226	3857.00	2893.00	2653.00	2199.00	2709.00	4499.00	16989	40272	14271	9120	6289	111977.00
69	5029	3734.00	3166.00	3138.00	2476.00	3078.00	13431.00	58282	45363	24184	7893	4751	174525.00
70	4239	3261.00	2948.00	2725.00	3103.00	2820.00	3018.00	26308	52592	23240	6762	4868	135884.00
71	4025	3196.00	2818.00	3110.00	2359.00	2453.00	3621.00	30514	55406	29124	9998	5168	151792.00
72	5401	4402.00	3106.00	3162.00	2233.00	3240.00	4673.00	22365	47800	13475	6234	4491	120582.00
73	4785	3373.00	2792.00	2302.00	2151.00	2497.00	3355.00	23951	26850	10965	5027	4073	92121.00
74	3073	3466.00	2600.00	3931.00	2270.00	3043.00	10536.00	34510	63100	22270	7847	4086	160732.00
75	3428	3004.00	3002.00	3097.00	2524.00	1965.00	2075.00	14775	56150	45094	10155	5156	150425.00
76	4888	3785.00	3262.00	2699.00	2277.00	2601.00	6635.00	34883	30735	15043	8758	8329	123895.00
77	5108	3476.00	2615.00	2284.00	1908.00	1801.00	3506.00	6185	23789	8236	4190	2781	65879.00
78	2761	1821.00	2271.00	2573.00	1891.00	2532.00	4423.00	17535	42080	25559	7189	9939	120574.00
79	5175	3980.00	3261.00	2749.00	2570.00	3079.00	4298.00	26017	20457	7648	5904	3309	88447.00
80	2759	2451.00	2176.00	2184.00	1914.00	1885.00	6206.00	30024	34944	26300	7780	6662	125285.00
81	4543	3798.00	3300.00	2737.00	2234.00	2588.00	8771.00	28302	40014	15348	5742	3671	121048.00
82	3859	3190.00	3068.00	2614.00	2089.00	2527.00	5643.00	32178	51855	36564	12037	6120	161744.00
83	6014	4183.00	3461.00	2655.00	1799.00	1882.00	3369.00	32464	66340	41148	16375	6753	186443.00
84	6927	11196.00	8612.00	7586.00	6317.00	6003.00	7572.00	35292	47554	31981	14343	8100	191483.00
85	5960	5034.00	4555.00	3410.00	2796.00	3802.00	8365.00	20219	18179	7955	4514	11326	96115.00

* " - " INDICATE ESTIMATED FLOWS

Table D.3

STATION: GOOSE CREEK AB TRAPPER CREEK NR OKLEY ID (13.0825.00)

WYEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANN
25	696.0	765.0	899.0	961.0	616	1981	4718.0	4879.0	1976.0	831.0	483.00	666.0	19471.00
26	899.0	1002.0	806.0	713.0	868	1925	2214.0	995.0	315.6	422.3	296.30	259.7	10715.90
27	593.0	822.0	635.0	682.0	2065	1530	2141.0	4696.0	2076.0	485.0	331.20	317.7	16373.90
28	665.0	862.0	480.0	930.0	1015	2527	2232.0	4375.0	1077.0	325.0	207.00	240.8	14935.80
29	529.0	693.0	589.0	558.0	530	1318	2822.0	5165.0	2190.0	485.1	347.20	398.7	15625.00
30	543.0	622.0	763.0	522.0	1074	1147	1332.0	1579.0	551.9	205.0	344.40	304.1	8987.40
31	590.0	608.0	565.0	545.0	690	1435	1421.0	720.0	295.5	58.2	96.80	152.6	7177.10
32	343.6	455.0	465.0	620.0	670	1818	2464.0	4988.0	2539.0	665.0	332.90	296.0	15656.50
33	476.0	660.0	490.0	558.0	500	1351	1514.0	3055.0	1934.0	396.2	183.30	185.1	11302.60
34	359.4	552.0	620.0	723.0	759	1039	777.2	413.9	231.1	28.3	10.10	75.9	5588.90
35	299.0	465.0	496.0	558.0	560	968	1472.0	2254.0	892.0	262.5	6.10	1.0	8233.60
36	153.9	428.0	487.0	558.0	580	979	3462.0	4037.0	1313.2	265.6	500.20	233.1	12997.00
37	442.3	577.0	527.0	496.0	560	1399	1800.0	3223.0	1071.7	354.5	105.60	79.9	10636.00
38	247.2	575.0	798.0	775.0	875	1336	2866.0	5098.0	1452.0	684.0	190.20	245.5	15141.90
39	388.2	662.0	744.0	713.0	616	4755	3336.0	1483.0	285.4	100.0	54.40	26.7	13163.70
40	299.4	443.0	542.0	775.0	750	1155	1895.0	1011.9	268.4	19.6	1.00	27.1	7187.40
41	213.3	378.0	446.0	558.0	801	1123	1853.0	2126.0	953.8	392.0	420.40	306.3	9570.80
42	497.0	737.0	813.0	713.0	672	2473	5822.0	7640.0	3646.0	686.0	209.10	170.5	24078.60
43	360.3	710.0	1005.0	2460.0	3115	2140	5333.0	3544.0	2848.0	615.0	244.20	152.4	22526.90
44	395.6	645.0	659.0	572.0	645	1430	2562.0	4361.0	2849.0	670.6	274.40	131.5	15195.10
45	338.4	558.0	433.0	677.0	1825	1547	2204.0	5576.0	2701.0	675.0	370.50	332.1	17237.00
46	528.0	835.0	1049.0	994.0	1096	2509	5421.0	5342.0	1558.0	479.3	273.40	335.7	20420.40
47	665.0	825.0	866.0	571.0	1365	1673	2025.0	1730.0	759.0	186.5	121.70	93.4	10880.60
48	350.5	586.0	731.0	634.0	1144	1222	2137.0	3577.0	1107.0	306.1	143.10	116.9	12054.60
49	280.9	513.0	574.0	497.0	445	2014	4900.0	6714.0	1875.0	327.3	195.70	185.8	18521.70
50	568.0	668.0	492.0	569.0	794	1419	3004.0	4764.0	2122.0	500.0	379.60	229.5	15509.10
51	509.0	721.0	965.0	767.0	4019	2695	4978.0	6696.0	1859.0	413.4	539.00	268.8	24430.20
52	550.0	615.0	568.0	566.0	624	1361	5501.0	9223.0	2589.0	872.0	685.00	398.0	23552.00
53	559.0	631.0	694.0	1173.0	924	1340	2505.0	4004.0	3208.0	674.0	651.60	327.6	16691.20
54	518.0	669.0	639.0	694.0	926	1286	1596.0	857.5	334.0	132.5	83.00	162.4	7897.40
55	439.0	583.0	491.5	512.0	556	1050	1190.0	1957.0	782.0	437.3	286.40	173.8	8458.00
56	426.0	625.0	997.0	1370.0	756	3368	3700.0	4050.0	925.9	224.5	163.20	120.6	16726.20
57	422.5	589.0	834.3	559.0	1782	1791	2283.0	6604.0	2310.0	398.7	254.40	211.1	18039.00
58	490.3	678.0	749.0	719.0	3232	1777	3300.0	7110.0	1873.0	492.0	390.20	257.5	21068.00
59	475.0	675.0	827.0	853.0	914	1134	1759.0	1073.0	493.6	240.3	133.90	278.7	8856.50
60	626.0	565.0	467.0	502.0	604	1778	2235.0	1544.0	350.8	175.5	135.70	173.5	9156.50
61	413.9	633.0	546.0	597.0	996	1261	1433.0	686.0	430.4	150.1	359.30	463.5	7969.20
62	521.0	626.0	688.0	2128.0	6749	3785	3842.0	2957.0	1778.0	402.0	373.10	230.8	24079.90
63	429.0	596.0	583.0	353.6	1084	1098	1285.0	2507.0	2294.0	470.8	202.50	341.8	11244.70
64	400.0	687.0	440.7	458.0	555	1364	2464.0	4685.0	3831.0	877.0	355.50	314.0	16431.20
65	440.4	672.0	1403.0	2435.0	2024	1387	3881.0	5673.0	2290.0	700.0	594.00	507.0	22006.40
66	633.0	742.6	632.2	687.0	736	1736	2076.0	811.9	254.0	61.7	42.32	41.8	8454.52
67	329.2	525.0	425.5	678.0	779	1051	1190.0	2348.0	2249.0	761.0	299.70	238.1	10873.50
68	426.6	457.0	366.6	471.0	1522	1507	1448.0	1052.0	444.9	163.8	469.90	396.0	8724.80
69	500.0	743.0	749.0	997.0	900	2104	4878.0	3122.0	833.0	435.0	213.80	212.6	15687.40
70	442.9	533.0	592.0	2484.0	1251	1120	1672.0	6928.0	3506.0	931.0	458.20	420.0	20338.10
71	609.0	813.0	942.0	5043.0	1969	2434	4801.0	9386.0	3604.0	841.0	554.00	409.0	31405.00
72	732.0	944.0	992.0	1412.0	1728	4145	4764.0	7962.0	3579.0	555.2	441.00	553.0	27807.20
73	966.0	1141.0	1172.0	1059.0	1301	2116	4151.0	7003.0	1560.0	570.8	513.00	585.0	22137.80
74	834.0	1087.0	891.0	780.0	1348	2941	5385.0	7080.0	1929.0	546.0	434.20	331.5	23586.70
75	668.0	869.0	704.0	902.5	1477	3096	2092.0	9428.0	9949.0	2087.0	966.00	653.0	32891.50
76	1052.0	1133.0	1308.0	915.0	1885	2972	4252.0	7283.0	1505.0	477.0	699.00	663.0	24144.00
77	889.0	946.0	863.0	847.0	902	1292	1327.0	1273.0	774.4	284.7	319.40	381.1	10098.60
78	563.0	703.0	932.0	1041.0	1012	1967	4055.0	5043.0	1524.0	368.2	326.60	613.0	18147.80
79	624.0	700.0	722.0	693.0	1989	3976	2717.0	5044.0	1447.0	364.5	476.70	402.0	19155.20
80	532.0	716.0	772.0	2761.0	2174	1389	3263.0	5718.0	3927.0	974.0	540.00	544.0	23310.00
81	698.0	847.0	981.0	857.0	901	1242	1670.0	1138.0	278.6	44.6	51.00	72.1	8780.30
82	427.4	668.0	928.0	782.0	2740	2278	3402.0	6955.0	2344.0	947.0	388.70	569.1	22429.20
83	860.0	955.0	920.0	897.0	1301	2329	3334.0	8184.0	4848.0	1230.0	993.00	671.0	26522.00
84	903.0	1003.0	1165.0	1244.0	1195	2927	5533.0	19379.0	9457.0	2614.0	1641.00	1186.0	48247.00
85	1416.0	1527.0	1084.0	1018.0	1057	2419	4625.0	3641.0	967.0	695.0	552.00	657.0	19658.00

* " - " INDICATE ESTIMATED FLOWS

Table D.4

STATION: CAMAS CREEK NR BLAINE ID (13.1415.00)

WYEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANN
25	-156.78	-223.62	-402.51	-403.33	-850.05	-3682.09	-54301.66	-26512.24	3225.0	549.0	186.6	167.1	-90659.98
26	-353.98	-481.86	-778.36	-585.79	-1081.10	-9253.70	5947.00	1137.00	167.4	86.6	66.5	82.9	-20022.19
27	-170.51	-274.62	-426.70	-521.87	-324.63	-4553.56	56009.00	26431.00	8658.0	1224.0	177.9	177.4	-98949.19
28	-446.61	-1126.38	-1102.07	-890.81	-2077.40	-10309.04	9170.00	5594.00	1020.0	279.2	122.1	98.0	-32235.61
29	-180.64	-324.64	-355.35	-372.53	-423.54	-3788.03	15617.00	5860.00	636.7	99.5	76.9	87.8	-27822.63
30	-154.64	-200.88	-297.49	-381.64	-1130.52	-5163.65	6443.00	5301.00	1359.2	123.0	70.1	77.9	-20703.02
31	-126.99	-91.50	-297.05	-20.66	-1.00	-113.71	4729.00	963.80	97.2	55.8	54.5	65.4	-6616.61
32	-120.82	-179.74	-841.83	-259.25	-218.58	-5084.81	30250.00	13658.00	8729.0	695.2	97.9	85.0	-60220.13
33	-144.92	-212.33	-221.13	-269.44	-230.94	-2045.56	-4956.70	13362.00	3609.0	192.4	69.4	85.1	-25398.92
34	-132.38	-239.62	-328.19	-360.66	-879.32	-5877.49	1969.00	373.40	89.6	61.8	55.8	73.2	-10440.46
35	-69.40	-110.86	-704.76	-207.16	-86.40	-3106.46	20777.00	4771.00	2250.1	104.7	61.7	55.2	-32304.74
36	77.80	-31.73	-416.28	-63.67	-308.40	-969.70	44438.00	12923.00	3311.2	122.6	96.1	74.4	-62832.88
37	107.50	-120.80	-646.87	-216.00	-249.40	-462.19	21975.00	5618.00	848.6	99.8	56.6	58.9	-30459.66
38	94.40	130.60	-252.72	-270.62	-680.37	-2717.85	73994.00	27287.00	6637.0	1942.0	166.6	144.6	-114317.76
39	366.90	-830.37	-1577.17	-696.73	-1003.70	-16519.27	14990.00	3126.00	347.5	122.5	70.3	61.8	-39712.24
40	-158.61	-198.74	-384.98	-299.17	-541.26	-4723.25	17494.00	5445.00	848.4	72.1	56.0	291.9	-30513.41
41	-269.65	-426.97	-275.40	-415.05	-830.22	7086.00	15155.00	6839.00	2813.0	313.1	148.1	159.9	-34731.39
42	-214.48	-435.08	-1544.78	-608.54	-841.05	-2101.16	-44987.37	11174.00	4403.0	415.8	96.0	88.9	-66910.16
43	-221.69	-482.40	-467.39	-613.79	-1120.78	-6272.85	106560.00	20442.00	9315.0	2295.0	265.4	226.5	-148282.80
44	415.60	672.00	-749.11	-587.85	-944.53	-2442.80	13843.00	6109.00	4176.0	583.4	136.7	120.8	-30780.79
45	176.80	363.40	276.00	705.00	1641.00	6829.00	21292.00	6293.00	3598.0	511.9	125.0	113.9	41925.00
46	195.80	320.80	374.00	392.00	349.00	2475.00	64735.00	13213.00	3350.0	388.9	128.9	133.8	86056.20
47	432.70	702.00	1754.00	620.00	5614.00	14289.00	7158.00	4570.00	1813.0	233.8	100.7	100.1	37387.30
48	149.20	284.00	336.40	316.00	1552.00	2804.00	14875.00	6736.00	2652.0	222.1	91.3	105.7	30123.70
49	139.00	295.90	310.00	310.00	358.00	1827.00	36563.00	9255.00	2044.0	199.4	91.0	95.9	51488.20
50	149.20	275.60	254.30	364.00	406.00	2236.00	52032.00	19078.00	6318.0	1214.8	299.7	253.7	82881.30
51	380.20	865.00	1130.00	775.00	1325.00	2346.00	56943.00	19993.00	4846.0	901.8	459.8	155.7	90120.50
52	425.40	689.00	881.00	775.00	702.00	875.00	99367.00	43597.00	9166.0	2641.0	502.0	312.6	159933.00
53	400.00	744.00	776.00	1313.00	1971.00	11714.00	28167.00	9567.00	6295.0	811.9	207.1	138.0	62104.00
54	229.70	388.60	665.00	594.00	903.00	5191.00	24905.00	7307.00	1674.0	642.2	133.9	111.6	42745.00
55	181.00	330.40	351.30	411.00	383.00	717.00	6285.00	7043.00	2204.0	322.7	104.6	91.0	18424.00
56	141.50	252.30	2058.20	3076.00	1938.00	5700.00	65176.00	18306.00	5624.0	488.5	148.9	116.5	103025.90
57	294.80	441.00	1760.00	558.00	6734.00	27548.00	22824.00	17283.00	6056.0	541.2	151.8	123.3	84315.10
58	245.10	336.00	445.00	618.00	918.00	2899.00	40878.00	26334.00	7644.0	849.8	159.9	202.7	81529.50
59	312.70	402.50	848.00	747.00	772.00	2905.00	15358.00	4262.00	603.0	148.5	96.2	321.6	26776.50
60	285.30	307.40	394.00	467.00	875.00	1370.00	34326.00	7528.00	1109.9	169.7	85.2	101.2	47018.70
61	139.90	232.50	300.80	290.30	1492.00	5548.00	6719.00	881.00	376.1	56.5	59.0	92.8	16187.90
62	142.90	163.90	269.20	634.00	2664.00	1447.00	48477.00	13963.00	7328.0	771.0	167.4	97.6	76125.00
63	245.50	389.30	680.00	509.00	31283.00	2423.00	4479.00	7764.00	6720.0	980.7	107.6	163.5	55744.60
64	256.50	625.00	589.00	527.00	580.00	866.00	27849.00	9858.00	4873.0	483.5	146.7	103.9	46757.60
65	238.00	385.00	13990.00	7640.00	8377.00	18172.00	56662.00	25534.00	13012.0	3937.0	1224.0	957.0	150128.00
66	1251.00	1535.00	1273.00	1288.00	1132.00	8066.00	23562.00	5011.00	1130.0	176.8	98.3	101.6	44624.70
67	173.10	398.10	408.00	674.00	792.00	3352.00	14826.00	14917.00	10449.0	2027.7	172.7	204.5	48394.10
68	338.00	538.00	499.00	569.00	1467.00	7907.00	3667.00	1455.00	2722.0	233.5	152.7	191.7	19739.90
69	255.90	467.90	459.00	916.00	1033.00	1486.00	83176.00	23195.00	6306.0	1496.7	180.5	226.0	119198.00
70	403.70	602.00	674.00	794.00	1043.00	7639.00	30808.00	14652.00	6785.0	1857.0	218.4	241.6	65717.70
71	477.10	1560.00	1769.00	1841.00	6389.00	16194.00	82010.00	32282.00	11911.0	2824.0	599.0	367.9	158224.00
72	846.00	1328.00	1223.00	1160.00	1251.00	43370.00	24666.00	15668.00	7904.0	1045.4	336.0	297.8	99095.20
73	703.00	1052.00	926.00	1017.00	1020.00	2497.00	22473.00	5906.00	1012.0	228.9	138.1	132.4	37105.40
74	207.00	969.00	959.00	1003.00	1159.00	29946.00	40739.00	15388.00	5046.0	584.4	149.1	128.0	96277.50
75	272.60	590.00	620.00	617.00	776.00	1668.00	23006.00	45552.00	8573.0	2876.0	264.6	285.4	85100.60
76	406.40	789.00	1143.00	845.00	925.00	1415.00	40671.00	10568.00	1809.0	267.8	214.9	279.1	59333.20
77	387.00	461.00	478.00	473.00	623.00	959.00	569.40	422.10	170.2	120.2	79.1	76.4	4818.40
78	96.50	200.30	596.90	521.00	660.00	8629.00	42615.00	15053.00	5660.0	1742.9	69.7	220.7	76065.00
79	253.10	331.80	422.00	363.60	560.00	8141.00	6212.00	3873.00	368.2	111.9	79.0	76.8	20792.40
80	178.20	257.70	273.00	439.80	1094.40	5077.00	21374.00	14834.00	6560.0	1431.9	139.1	154.8	51813.90
81	325.20	447.00	787.00	834.00	1615.00	5804.00	5242.00	4224.00	2101.0	100.4	65.9	62.3	21607.80
82	137.30	371.20	811.00	650.00	1190.00	7823.00	62423.00	31912.00	10919.0	2663.0	218.0	382.0	119499.50
83	613.00	1039.00	968.00	1175.00	1298.00	23302.00	62200.00	48124.00	18642.0	5102.0	858.0	495.0	163816.00
84	1230.00	2480.00	1618.00	2032.00	2525.00	5516.00	65561.00	32049.00	12798.0	2418.0	639.0	468.0	129334.00
85	880.00	1595.00	1147.00	1114.00	1057.00	1572.00	34725.00	8198.00	1603.0	190.2	157.9	322.6	52561.70

* " - " INDICATE ESTIMATED FLOWS

Table D.5

Summary of the Monthly Statistics for
Big Wood Slough Station (13.1395.10)

Period	N (Years)	Minimum (Cfs-days)	Maximum (Cfs-days)	Mean (Cfs-days)	Std Dev (Cfs-days)
OCT	61	2611.00	13048.78	6398.59	2062.06
NOV	61	2773.00	12423.81	5728.89	1619.84
DEC	61	2948.00	9637.41	5085.69	1209.23
JAN	61	2461.00	8533.27	4854.58	1131.01
FEB	61	2753.00	7509.15	4334.41	878.77
MAR	61	3335.00	10385.00	5641.74	1545.97
APR	61	4949.00	42529.00	16268.01	8207.09
MAY	61	7333.32	94200.00	40975.84	20369.49
JUN	61	7055.00	98468.14	44318.03	23038.84
JUL	61	3430.00	55299.00	20595.04	12473.89
AUG	61	2322.00	21248.00	8371.04	3979.82
SEP	61	2064.00	13367.00	6387.72	2506.95
ANN	61	61869.00	306877.00	168959.57	63704.88

Table D.6

Summary of the Monthly Statistics for
Big Lost River Station (13.1205.00)

Period	N (Years)	Minimum (Cfs-days)	Maximum (Cfs-days)	Mean (Cfs-days)	Std Dev (Cfs-days)
OCT	61	1799.00	6927.00	3808.33	1275.72
NOV	61	1821.00	11196.00	3157.11	1255.94
DEC	61	1713.21	8612.00	2744.38	923.36
JAN	61	1571.24	7586.00	2546.73	820.57
FEB	61	1319.89	6317.00	2181.06	641.80
MAR	61	1459.00	6003.00	2441.84	645.26
APR	61	1524.86	14543.00	5706.17	3027.73
MAY	61	6185.00	58282.00	24826.43	10486.61
JUN	61	6619.00	70440.00	36078.48	15469.58
JUL	61	2897.00	45609.00	18051.84	10691.49
AUG	61	1679.00	18170.00	6541.61	3274.92
SEP	61	1430.00	11326.00	4263.64	1919.26
ANN	61	45775.49	196254.00	112347.59	36958.46

Table D.7

Summary of the Monthly Statistics for
Goose Creek Station (13.0825.00)

Period	N (Years)	Minimum (Cfs-days)	Maximum (Cfs-days)	Mean (Cfs-days)	Std Dev (Cfs-days)
OCT	61	153.90	1416.00	541.72	219.83
NOV	61	378.00	1527.00	709.24	201.34
DEC	61	366.60	1403.00	737.83	233.90
JAN	61	353.60	5043.00	953.89	747.29
FEB	61	445.00	6749.00	1287.57	1016.54
MAR	61	968.00	4755.00	1897.20	856.86
APR	61	777.20	5822.00	2955.97	1404.60
MAY	61	413.90	19379.00	4454.95	3163.68
JUN	61	231.10	9949.00	1954.36	1821.06
JUL	61	19.60	2614.00	525.19	434.84
AUG	61	1.00	1641.00	355.87	270.08
SEP	61	1.00	1186.00	317.89	212.87
ANN	61	5588.90	48247.00	16691.70	7725.01

Table D.8

Summary of the Monthly Statistics for
Camas Creek Station (13.1415.00)

Period	N (Years)	Minimum (Cfs-days)	Maximum (Cfs-days)	Mean (Cfs-days)	Std Dev (Cfs-days)
OCT	61	69.40	1251.00	304.58	242.82
NOV	61	31.73	2480.00	534.43	444.78
DEC	61	221.13	13990.00	943.71	1759.27
JAN	61	20.66	7640.00	787.09	1016.07
FEB	61	1.00	31283.00	1840.49	4141.98
MAR	61	113.71	43370.00	6669.13	7899.88
APR	61	569.40	106560.00	32609.85	25500.48
MAY	61	373.40	48124.00	13517.62	11282.40
JUN	61	89.60	18642.00	4628.12	3962.87
JUL	61	55.80	5102.00	876.28	1054.50
AUG	61	54.50	1224.00	189.38	202.74
SEP	61	55.20	957.00	178.51	144.43
ANN	61	4818.40	163816.00	63079.19	41610.51

APPENDIX E

PAIRING INFORMATION

Table E.1

Pairing Information between
13.1395.10 & 13.1205.00

1. Overlap Record : 25 years (1949 -1973)

2. Correlation Coefficients for the Months Needed to Fill in the Missing Records of Station 13.1205.00

Month	Corr. Coeff.
November	0.830
December	0.738
January	0.788
Feburary	0.509
March	0.743
April	0.945

3. Location of the Two Stations

Station 13.1395.10 :	Latitude	43° 31' 05"
	Longitude	114° 19' 10"
Station 13.1205.00 :	Latitude	43° 59' 54"
	Longitude	114° 01' 12"

APPENDIX F

COMPARISONS OF SIMPLE STATISTICS

Table F.1

Test for Normality for Station 13.1395.10

Period (Month)	Raw Skew Coeff. (Trans Skew Coeff.)	*g (95%)	*n	Normal (yes/no)
October	0.113	±0.69	49	yes
November	0.047	±0.69	49	yes
December	0.010	±0.69	49	yes
January	0.221	±0.69	49	yes
Feburary	0.226	±0.69	49	yes
March	1.175(0.384)	±0.69	49	no(yes)
April	1.221(0.110)	±0.69	49	no(yes)
May	0.990(0.033)	±0.69	49	no(yes)
June	0.470	±0.69	49	yes
July	1.114(-0.404)	±0.69	49	no(yes)
August	1.296(-0.213)	±0.69	49	no(yes)
September	0.888(-0.407)	±0.69	49	yes

* g(95%) = 95% critical skew coefficient for hypothesis that g = 0.
* n = sample size
* g(95%) = $\pm 1.96\,(6/n)^{1/2}$

Table F.2

Test for Normality for Station 13.1205.00

Period (Month)	Raw Skew Coeff. (Trans Skew Coeff.)	*g (95%)	*n	Normal (yes/no)
October	0.387	±0.63	59	yes
November	-0.061	±0.72	45	yes
December	-0.322	±0.81	35	yes
January	0.243	±0.81	35	yes
Feburary	-0.068	±0.81	35	yes
March	0.031	±0.81	35	yes
April	0.989(0.054)	±0.66	53	no(yes)
May	0.766(-0.478)	±0.63	59	no(yes)
June	0.267	±0.63	59	yes
July	0.869(-0.434)	±0.63	59	no(yes)
August	1.370(-0.231)	±0.63	59	no(yes)
September	1.114(0.000)	±0.63	59	no(yes)

* g(95%) = 95% critical skew coefficient for hypothesis that g = 0.
* n = sample size
* g(95%) = $\pm 1.96\,(6/n)^{1/2}$

* The records of 1984-1985 water years were considered as outliers.

Table F.3

Test for Normality for the Common Period
between 13.1395.10 & 13.1205.00

Period (Month)	Skew Coeff. (13.1395.10)	Skew coeff. (13.1205.00)	*g (95%)	*n	Normal (yes/no)
October	0.113	0.477	0.69	49	yes
November	0.303	0.083	0.85	32	yes
December	-0.201	-0.238	-0.96	25	yes
January	0.421	0.075	0.96	25	yes
Feburary	0.455	-0.124	-0.96	25	yes
March	0.918	-0.022	-0.96	25	yes
April	0.130	0.199	0.85	32	yes
May	0.033	-0.076	-0.96	49	yes
June	0.470	0.301	0.69	49	yes
July	-0.404	-0.494	-0.69	49	yes
August	-0.213	-0.274	-0.69	49	yes
September	-0.407	-0.607	-0.69	49	yes

* g(95%) = 95% critical skew coefficient for hypothesis that g = 0.
* n = sample size
* g(95%) = $\pm 1.96 (6/n)^{1/2}$

* The records of 1984-1985 water years for 13.1205.00 were considered as outliers.

Table F.4

Simple Statistics between Original and Filled-in Stream Flows for Station 13.1205.00 (for 1925-1983 water years)

Period (Month)	Mean (Cfs-days) Origin	Mean (Cfs-days) Filled	Stand Dev (Cfs-days) Origin	Stand Dev (Cfs-days) Filled	Skew Coef Origin	Skew Coef Filled
October	3719	3719	1195	1195	0.387	0.387
November	3048	2989	646	654	-0.061	0.020
December	2685	2614	505	463	-0.322	-0.192
January	2537	2447	542	485	0.243	0.320
Feburary	2160	2101	380	344	-0.068	-0.001
March	2380	2358	417	416	0.031	0.094
April	5713	5629	3135	3049	0.989	0.985
May	24727	24727	10559	10559	0.766	0.766
June	36187	36187	15484	15484	0.267	0.267
July	17987	17987	10637	10637	0.869	0.869
August	6444	6444	3157	3157	1.370	1.370
September	4079	4079	1632	1632	1.114	1.114

* The records of 1984-1985 water years were considered as outliers.

* The months of October and May through September have a complete historical flow record for 1925-1985.

APPENDIX G

THE SIMPLE STATISTICS AND THE RESULTS COMPARISONS

Table G.1

Coefficients of Skew for Transformed and Untransformed Monthly Streamflow
Station: 13.1205.00
Period: 1949 - 1983 Water Years

Month	Skew Coeff Raw	Skew Coeff Trans(Log)
October	0.4034	*-0.1069
November	*-0.0233	-0.4487
December	*-0.3215	-0.6207
January	* 0.2431	-0.2756
Feburary	*-0.0679	-0.6402
March	* 0.0308	-0.4604
April	1.0014	* 0.0768
May	* 0.6535	-0.6663
June	* 0.3053	-0.4008
July	0.8215	*-0.3954
August	1.4843	* 0.1128
September	1.2188	* 0.2900

* " * " indicate the series used for modeling.
* g(95%) = 95% critical skew coefficient for hypothesis that g = 0.
* n = sample size
* g(95%) = $1.96\,(6/n)^{1/2}$
$= 1.96\,(6/35)^{1/2}$
$= 0.81$
* The records of 1984-1985 water years were considered as outliers.

Table G.2

Statistics of Untransformed/Transformed Values
as Calculated from Moment Relationships
Station: 13.1205.00
Period: 1949 - 1983 Water Years

Month	Mean (Cfs-days)	Standard Dev. (Cfs-days)	Lag-1 Ser Corr Coef
* October	8.229498	0.274755	0.85284
November	3074.343	672.5527	0.92188
December	2684.886	504.7803	0.77161
January	2536.514	541.9309	0.71840
Feburary	2159.637	379.5883	0.67542
March	2379.714	416.8587	0.62542
* April	8.479447	0.505448	0.42883
May	26353.940	11791.680	0.54360
June	40756.860	14766.720	0.41385
* July	9.773793	0.580517	0.91088
* August	8.810586	0.428249	0.84596
* September	8.363622	0.354542	0.68690

* " * " indicate the transformed monthly values.
* The records of 1984-1985 water years were considered as outliers.

Table G.3

Correlation Coefficients between
Monthly and Annual Values
Station: 13.1205.00
Period: 1949 - 1983 Water Years

Month	Corr Coeff Raw	Corr Coeff Trans(Log)
October	0.01460	* 0.01488
November	* 0.08379	
December	* 0.38240	
January	* 0.48597	
Feburary	* 0.32636	
March	* 0.26703	
April	0.27781	* 0.29654
May	* 0.69817	
June	* 0.89770	
July	0.85278	* 0.92994
August	0.84014	* 0.88017
September	0.50976	* 0.52621

* " * " indicate the series used for modeling.
* The records of 1984-1985 water years were considered as outliers.

Table G.4

Parameters for Lane's Disaggregation Model
Station: 13.1205.00

Month	Q	H	GG^T
October	-0.60004	1.16859	0.012310
Novembeer	0.07009	0.92084	0.145226
December	0.31999	0.74480	0.302941
January	0.24744	0.62378	0.431630
Feburary	-0.00245	0.67661	0.543803
March	0.07042	0.60244	0.604419
April	0.19601	0.37649	0.780426
May	0.58874	0.36901	0.388361
June	1.18769	-0.41536	0.105705
July	0.57817	0.39186	0.105402
August	0.69135	0.20305	0.219726
September	-0.34789	0.99310	0.500902

Table G.5

Difference between Annual Flows Generated by Multivariate AR (1) Modeling and Generated or Actual Monthly Sum Flows by Disaggregation Model Approach
Station: 13.1205.00

Water Year	AR (1) (Cfs-days)	Gen or Actual (Cfs-days)	Difference (Cfs-days)
25	126313	120571	5742
26	88710	58233	30476
27	137338	112687	24650
28	99450	92022	7428
29	53180	65568	-12388
30	94834	92925	1909
31	72530	51010	21520
32	112269	107147	5122
33	94562	73842	20719
34	81374	42841	38532
35	118116	101554	16561
36	109967	74910	35056
37	93563	52035	41528
38	173830	165480	8350
39	87430	67299	20131
40	101394	83473	17921
41	117496	103495	14000
42	129348	109914	19434
43	173233	160562	12670
44	98169	129334	-31165
45	104327	95973	8354
46	132368	107540	24828
47	123447	106200	17246
48	95335	112301	-16966

* "AR (1)"indicates annual flows generated by multivariate AR (1) modeling
* "Gen or Actual" indicates generated or actual monthly sum flows by Disaggregation Modeling
* Difference" indicates "Annual" minus "Gen/Actual" for each year

Table G.6

Difference between Annual Flows Generated by Multivariate AR (1) Modeling and Generated or Actual Monthly Sum Flows by Multivariate AR (1) Modeling
Station: 13.1205.00

Water Year	AR (1) (Cfs-days)	Gen or Actual (Cfs-days)	Difference (Cfs-days)
25	126313	119519	6794
26	88710	59361	29348
27	137338	114556	22781
28	99450	95518	3931
29	53180	61845	-8665
30	94834	92505	2329
31	72530	52778	19751
32	112269	105450	6818
33	94562	73845	20717
34	81374	45775	35598
35	118116	102440	15676
36	109967	77767	32199
37	93563	55520	38043
38	173830	165730	8100
39	87430	72022	15408
40	101394	88379	13015
41	117496	102337	15158
42	129348	113746	15601
43	173233	159419	13814
44	98169	128971	-30802
45	104327	94246	10081
46	132368	108018	24350
47	123447	108713	14733
48	95335	110826	-15491

* "AR (1)" indicates annual flows generated by multivariate AR (1) modeling
* "Gen or Actual" indicates generated or actual monthly sum flows by multivariate AR (1) modeling
* "Difference" indicates "Annual" minus "Gen or Actual" for each year

APPENDIX H

COMPARISONS OF CORRELATION COEFFICIENTS

Table H.1

Comparisons of Correlation Coefficients with Camas Creek station (13.1415.00)

Month	Corr Coeff (13.1395.10)	Corr Coeff (13.0825.00)
October	0.8959	0.6107
November	0.8951	0.5010
December	0.9108	0.4687
January	0.5304	0.5619
Feburary	0.1375	0.7712
March	0.8272	0.3431
April	0.7450	0.7928
May	0.8102	0.7066
June	0.8762	0.7264
July	0.8437	0.6700
August	0.7664	0.7833
September	0.7362	0.2480

APPENDIX I

COMPARISONS OF PARAMETER ESTIMATES BETWEEN SIMPLE REGRESSION AND QUADRATIC REGRESSION

Table I.1

Coefficients of Determinations for Simple Regression and Quadratic Regression between 13.1415.00 and 13.1395.10 for 1925 -1952 Water Years

Month	Simple Regr $Y=a+bX$ (R-square)	Quadratic Regr $Y=a+bX+cX^2$ (R-square)
October	0.8027	0.8163
November	0.8012	0.8432
December	0.8295	0.9780
January	0.2813	0.2818
February	0.0189	0.0384
March	0.6842	0.8121
April	0.5550	0.5908
May	0.6565	0.7052
June	0.7678	0.7690
July	0.7118	0.7202
August	0.5873	0.5956
September	0.5420	0.5527

Table I.2

Parameter Estimates for Polynomial(Quadratic) Regression between 13.1395.10 & 13.1415.00

Month	α	β1	β2	R-square
Oct	38.453489	-0.001828	0.000005429	0.8163
Nov	255.725374	-0.140126	0.000030066	0.8432
Dec	6040.750890	-2.718566	0.000319000	0.9780
Jan	-163.157607	0.078357	0.000013819	0.2818
Feb	-7250.519943	3.623326	-0.000396000	0.0384
Mar	16953.00000	-6.393593	0.000712000	0.8121
Apr	11027.00000	0.128879	0.000055448	0.5908
May	3376.691743	-0.035157	0.000005342	0.7052
Jun	-1656.479140	0.147518	-0.000000214	0.7690
Jul	-211.566985	0.035845	0.000000395	0.7202
Aug	-0.482180	0.012469	0.000001012	0.5956
Sep	38.332898	0.004019	0.000002225	0.5527

APPENDIX J

TEST FOR NORMALITY FOR KEY STATION AND SUBORDINATE STATIONS

Table J.1

Tests of Normality for Key Station and Subordinate Stations

	Camas Creek Skew Coeff		Big Wood Skew Coeff		Big Lost Skew Coeff		Goose Creek Skew Coeff	
Month	Raw	Trans	Raw	Trans	Raw	Trans	Raw	Trans
Oct	0.8896	*0.2176	0.2616	-0.2558	0.5967	-0.0405	0.4753	-0.5564
Nov	1.1810	*-0.6516	0.2172	-0.2189	-0.1207	-0.4092	0.3394	-0.2303
Dec	1.3869	*0.6326	0.2349	-0.0896	-0.0893	-0.5706	0.6530	0.3317
Jan	*0.1997	-2.1923	-0.0122	-0.3700	-0.4359	-0.7971	4.2153 (1.0747)	2.6428
Feb	*3.5363 (0.7684)	-2.8151	0.1343	-0.1077	-0.4569	-0.9329	2.5968 (1.8701)	1.4243
Mar	*1.6143 (0.8774)	-1.2267	0.9138	0.4151	0.3149	-0.1452	2.4056 (0.8008)	1.0247
Apr	1.1358	*-0.3736	1.0684	0.0164	0.7031	-0.3777	0.7441	-0.0742
May	*1.4835 (0.9065)	-0.9812	0.8863	-0.2373	0.3845	-0.2892	0.3327	-1.0337
Jun	0.8445	*-1.0721	0.5177	-0.8050	0.2726	-0.8584	0.2673	-0.8093
Jul	1.9066	*0.3814	1.1451	-0.3376	0.7510	-0.4591	0.0753	-1.7088
Aug	2.1844	*0.9647	0.7083	-0.1933	0.4282	-0.4090	0.4466	-2.2573
Sep	1.4223	*0.6248	0.1830	-0.5206	-0.2704	-0.6931	0.9514	-2.7918

* The records of 1925-1952 water years were used to test for normality
* " * " indicates the series used for modeling.
* g(95%) = 95% critical skew coefficient for hypothesis that g = 0.
* n = sample size
* g(95%) = $1.96\,(6/n)^{1/2}$
= $1.96\,(6/28)^{1/2}$
= 0.907
* " ( ) " for Camas Creek indicates Feb. 1947, Mar. 1939 and 1947, and May 1952 were considered as outliers.
* " ( ) " for Gooses Creek indicates Jan. 1943, Feb. 1943 and 1951, and Mar. 1939 were considered as outliers.

APPENDIX K

CORRELATION COEFFICIENTS BETWEEN

MONTHLY FLOWS

(CFS-DAYS)

Table K.1

CORRELATION COEFFICIENTS
BETWEEN MONTHLY FLOWS
1 = BIG WOOD, 2 = BIG LOST, 3 = GOOSE CREEK, 4 = CAMAS CREEK

Variable	N	Mean	Std Dev	Sum	Minimum	Maximum
OCT1	28	8.541892	0.354379	239.172962	7.867489	9.089641
OCT2	28	8.097034	0.367524	226.716959	7.494986	8.818334
OCT3	28	6.053035	0.395468	169.484990	5.036303	6.801283
OCT4	28	5.233940	0.533021	146.550315	4.239887	6.101686
LAG1OCT1	27	8.473191	0.378084	228.776154	7.632401	9.020511
LAG1OCT2	27	8.069438	0.382967	217.874824	7.265430	8.515592
LAG1OCT3	27	5.005293	1.244379	135.142909	0	6.501290
LAG1OCT4	27	4.684652	0.447649	126.485605	4.010963	5.676411

	OCT1	OCT2	OCT3	OCT4	LAG1OCT1	LAG1OCT2	LAG1OCT3	LAG1OCT4
OCT1	1.00000	0.92185	0.31319	0.85196	0.95297	0.92546	0.27485	0.77709
OCT2	0.92185	1.00000	0.23600	0.73390	0.84157	0.93142	0.21805	0.69693
OCT3	0.31319	0.23600	1.00000	0.49164	0.39827	0.34107	0.85493	0.30299
OCT4	0.85196	0.73390	0.49164	1.00000	0.85251	0.77892	0.44698	0.83358

Table K.2

CORRELATION COEFFICIENTS
BETWEEN MONTHLY FLOWS
1 = BIG WOOD, 2 = BIG LOST, 3 = GOOSE CREEK, 4 = CAMAS CREEK

Variable	N	Mean	Std Dev	Sum	Minimum	Maximum
NOV1	28	8.485492	0.285579	237.593772	7.927685	8.943245
NOV2	28	7.946928	0.213887	222.513980	7.532088	8.269365
NOV3	28	6.439014	0.233964	180.292380	5.934894	6.909753
NOV4	28	5.678691	0.782915	159.003349	3.457263	7.026764
LAG1NOV1	28	8.541892	0.354379	239.172962	7.867489	9.089641
LAG1NOV2	28	8.097034	0.367524	226.716959	7.494986	8.818334
LAG1NOV3	28	6.053035	0.395468	169.484990	5.036303	6.801283
LAG1NOV4	28	5.233940	0.533021	146.550315	4.239887	6.101686

	NOV1	NOV2	NOV3	NOV4	LAG1NOV1	LAG1NOV2	LAG1NOV3	LAG1NOV4
NOV1	1.00000	0.87013	0.44786	0.81136	0.93751	0.86226	0.28746	0.85654
NOV2	0.87013	1.00000	0.35752	0.66464	0.86183	0.78615	0.21940	0.75308
NOV3	0.44786	0.35752	1.00000	0.52775	0.38237	0.28334	0.85604	0.53513
NOV4	0.81136	0.66464	0.52775	1.00000	0.72976	0.61385	0.47084	0.91437

Table K.3

CORRELATION COEFFICIENTS
BETWEEN MONTHLY FLOWS
1 = BIG WOOD, 2 = BIG LOST, 3 = GOOSE CREEK, 4 = CAMAS CREEK

Variable	N	Mean	Std Dev	Sum	Minimum	Maximum
DEC1	28	8.389551	0.224428	234.907442	7.988882	8.748940
DEC2	28	7.830304	0.180190	219.248517	7.446124	8.177516
DEC3	28	6.458765	0.266482	180.845409	6.070738	6.955593
DEC4	28	6.230789	0.619597	174.462104	5.398751	7.469654
LAG1DEC1	28	8.485492	0.285579	237.593772	7.927685	8.943245
LAG1DEC2	28	7.946928	0.213887	222.513980	7.532088	8.269365
LAG1DEC3	28	6.439014	0.233964	180.292380	5.934894	6.909753
LAG1DEC4	28	5.678691	0.782915	159.003349	3.457263	7.026764

	DEC1	DEC2	DEC3	DEC4	LAG1DEC1	LAG1DEC2	LAG1DEC3	LAG1DEC4
DEC1	1.00000	0.66630	0.43023	0.46261	0.87839	0.77350	0.48012	0.81399
DEC2	0.66630	1.00000	0.24905	0.50128	0.56669	0.71636	0.22299	0.42322
DEC3	0.43023	0.24905	1.00000	0.27546	0.24916	0.15403	0.60388	0.32150
DEC4	0.46261	0.50128	0.27546	1.00000	0.43368	0.41322	0.34835	0.51847

Table K.4

CORRELATION COEFFICIENTS
BETWEEN MONTHLY FLOWS
1 = BIG WOOD, 2 = BIG LOST, 3 = GOOSE CREEK, 4 = CAMAS CREEK

Variable	N	Mean	Std Dev	Sum	Minimum	Maximum
JAN1	28	4211.750000	877.946452	117929	2461.000000	5784.000000
JAN2	28	2340.795714	385.934512	65542	1571.240000	3100.000000
JAN3	28	723.750000	366.421294	20265	496.000000	2460.000000
JAN4	28	439.341429	218.864865	12302	20.660000	890.810000
LAG1JAN1	28	4507.892857	999.619718	126221	2948.000000	6304.000000
LAG1JAN2	28	2554.114286	441.235570	71515	1713.210000	3560.000000
LAG1JAN3	28	660.964286	182.050152	18507	433.000000	1049.000000
LAG1JAN4	28	620.922857	438.298588	17386	221.130000	1754.000000

	JAN1	JAN2	JAN3	JAN4	LAG1JAN1	LAG1JAN2	LAG1JAN3	LAG1JAN4
JAN1	1.00000	0.69156	0.21841	0.74118	0.92060	0.66276	0.34711	0.46727
JAN2	0.69156	1.00000	0.04304	0.48262	0.65323	0.95444	0.29122	0.50411
JAN3	0.21841	0.04304	1.00000	0.27728	0.18599	-0.03608	0.52514	-0.02102
JAN4	0.74118	0.48262	0.27728	1.00000	0.81367	0.53090	0.29648	0.57569

Table K.5

CORRELATION COEFFICIENTS
BETWEEN MONTHLY FLOWS
1 = BIG WOOD, 2 = BIG LOST, 3 = GOOSE CREEK, 4 = CAMAS CREEK

Variable	N	Mean	Std Dev	Sum	Minimum	Maximum
FEB1	28	3845.642857	696.903799	107678	2753.000000	5032.000000
FEB2	28	2026.411786	302.813212	56740	1319.890000	2670.000000
FEB3	28	1045.464286	815.737044	29273	445.000000	4019.000000
FEB4	28	920.363929	1048.472300	25770	1.000000	5614.000000
LAG1FEB1	28	4211.750000	877.946452	117929	2461.000000	5784.000000
LAG1FEB2	28	2340.795714	385.934512	65542	1571.240000	3100.000000
LAG1FEB3	28	723.750000	366.421294	20265	496.000000	2460.000000
LAG1FEB4	28	439.341429	218.864865	12302	20.660000	890.810000

	FEB1	FEB2	FEB3	FEB4	LAG1FEB1	LAG1FEB2	LAG1FEB3	LAG1FEB4
FEB1	1.00000	0.43986	0.43021	0.48999	0.88005	0.64148	0.38894	0.77492
FEB2	0.43986	1.00000	0.36307	0.25092	0.34431	0.86924	0.03098	0.23766
FEB3	0.43021	0.36307	1.00000	0.26181	0.24432	0.33895	0.54039	0.46215
FEB4	0.48999	0.25092	0.26181	1.00000	0.30578	0.28850	0.06303	0.48910

Table K.6

CORRELATION COEFFICIENTS
BETWEEN MONTHLY FLOWS
1 = BIG WOOD, 2 = BIG LOST, 3 = GOOSE CREEK, 4 = CAMAS CREEK

Variable	N	Mean	Std Dev	Sum	Minimum	Maximum
MAR1	28	5205.428571	1518.290936	145752	3335.000000	8928.000000
MAR2	28	2312.573214	393.618363	64752	1578.240000	3179.170000
MAR3	28	1723.892857	774.988905	48269	968.000000	4755.000000
MAR4	28	4641.220357	3950.611648	129954	113.710000	16519
LAG1MAR1	28	3845.642857	696.903799	107678	2753.000000	5032.000000
LAG1MAR2	28	2026.411786	302.813212	56740	1319.890000	2670.000000
LAG1MAR3	28	1045.464286	815.737044	29273	445.000000	4019.000000
LAG1MAR4	28	920.363929	1048.472300	25770	1.000000	5614.000000

	MAR1	MAR2	MAR3	MAR4	LAG1MAR1	LAG1MAR2	LAG1MAR3	LAG1MAR4
MAR1	1.00000	0.83289	0.54901	0.85395	0.63083	0.33784	0.20292	0.62271
MAR2	0.83289	1.00000	0.32674	0.66142	0.40968	0.61065	0.06100	0.47405
MAR3	0.54901	0.32674	1.00000	0.53315	0.48161	0.17689	0.21796	0.13194
MAR4	0.85395	0.66142	0.53315	1.00000	0.33101	0.09471	0.09354	0.63663

Table K.7

CORRELATION COEFFICIENTS
BETWEEN MONTHLY FLOWS
1 = BIG WOOD, 2 = BIG LOST, 3 = GOOSE CREEK, 4 = CAMAS CREEK

Variable	N	Mean	Std Dev	Sum	Minimum	Maximum
APR1	28	9.612431	0.504628	269.148055	8.654692	10.657941
APR2	28	8.576400	0.588622	240.139206	7.329658	9.584865
APR3	28	7.861373	0.512144	220.118457	6.655698	8.669399
APR4	28	9.963909	1.028273	278.989454	7.585281	11.576463
LAG1APR1	28	8.519393	0.276800	238.543016	8.112228	9.096948
LAG1APR2	28	7.732082	0.171309	216.498307	7.364066	8.064375
LAG1APR3	28	7.380541	0.363859	206.655153	6.875232	8.466952
LAG1APR4	28	8.052476	1.041808	225.469315	4.733651	9.712283

	APR1	APR2	APR3	APR4	LAG1APR1	LAG1APR2	LAG1APR3	LAG1APR4
APR1	1.00000	0.93205	0.65462	0.56359	0.47756	0.33835	0.37465	0.21660
APR2	0.93205	1.00000	0.51352	0.35276	0.52630	0.42163	0.32782	0.20887
APR3	0.65462	0.51352	1.00000	0.81907	0.07385	0.00000	0.57080	0.00000
APR4	0.56359	0.35276	0.81907	1.00000	0.00000	0.00000	0.23488	0000000

Table K.8

CORRELATION COEFFICIENTS
BETWEEN MONTHLY FLOWS
1 = BIG WOOD, 2 = BIG LOST, 3 = GOOSE CREEK, 4 = CAMAS CREEK

Variable	N	Mean	Std Dev	Sum	Minimum	Maximum
MAY1	28	38269	18019	1071544	12906	84650
MAY2	28	23455	8658.076784	656727	9231.000000	42195
MAY3	28	3902.350000	2212.791502	109266	413.900000	9223.000000
MAY4	28	11631	10069	325661	373.400000	43597
LAG1MAY1	28	16876	8616.006965	472522	5737.000000	42529
LAG1MAY2	28	6182.719286	3318.330109	173116	1524.860000	14543
LAG1MAY3	28	2935.935714	1487.571602	82206	777.200000	5822.000000
LAG1MAY4	28	32735	28691	916571	1969.000000	106560

	MAY1	MAY2	MAY3	MAY4	LAG1MAY1	LAG1MAY2	LAG1MAY3	LAG1MAY4
MAY1	1.00000	0.91536	0.56728	0.82623	0.67970	0.50561	0.58643	0.79556
MAY2	0.91536	1.00000	0.41117	0.56963	0.64550	0.51105	0.51859	0.58327
MAY3	0.56728	0.41117	1.00000	0.68586	0.33154	0.25323	0.74172	0.64621
MAY4	0.82623	0.56963	0.68586	1.00000	0.51481	0.31662	0.57878	0.85627

Table K.9

CORRELATION COEFFICIENTS
BETWEEN MONTHLY FLOWS
1 = BIG WOOD, 2 = BIG LOST, 3 = GOOSE CREEK, 4 = CAMAS CREEK

Variable	N	Mean	Std Dev	Sum	Minimum	Maximum
JUN1	28	37074	19540	1038084	7055.000000	85100
JUN2	28	29925	13607	837906	6619.000000	62820
JUN3	28	1547.700000	940.739083	43336	231.100000	3646.000000
JUN4	28	3440.282143	2891.577682	96328	89.600000	9315.000000
LAG1JUN1	28	38269	18019	1071544	12906	84650
LAG1JUN2	28	23455	8658.076784	656727	9231.000000	42195
LAG1JUN3	28	3902.350000	2212.791502	109266	413.900000	9223.000000
LAG1JUN4	28	11631	10069	325661	373.400000	43597

	JUN1	JUN2	JUN3	JUN4	LAG1JUN1	LAG1JUN2	LAG1JUN3	LAG1JUN4
JUN1	1.00000	0.95338	0.56674	0.87625	0.73808	0.49213	0.53473	0.78267
JUN2	0.95338	1.00000	0.53945	0.78191	0.62565	0.40767	0.46829	0.66214
JUN3	0.56674	0.53945	1.00000	0.69939	0.34718	0.15280	0.80623	0.52689
JUN4	0.87625	0.78191	0.69939	1.00000	0.64790	0.39202	0.60108	0.81009

Table K.10

CORRELATION COEFFICIENTS
BETWEEN MONTHLY FLOWS
1 = BIG WOOD, 2 = BIG LOST, 3 = GOOSE CREEK, 4 = CAMAS CREEK

Variable	N	Mean	Std Dev	Sum	Minimum	Maximum
JUL1	28	9.542739	0.680947	267.196699	8.140316	10.808353
JUL2	28	9.415818	0.667049	263.642901	7.971431	10.498002
JUL3	28	5.754848	0.954340	161.135754	2.975530	6.770789
JUL4	28	5.700640	1.135907	159.617921	4.021774	7.878913
LAG1JUL1	28	10.355118	0.636345	289.943298	8.861492	11.351582
LAG1JUL2	28	10.183565	0.543623	285.139811	8.797700	11.048029
LAG1JUL3	28	7.086885	0.822352	198.432791	5.442851	8.201386
LAG1JUL4	28	7.594487	1.316030	212.645638	4.495355	9.139381

	JUL1	JUL2	JUL3	JUL4	LAG1JUL1	LAG1JUL2	LAG1JUL3	LAG1JUL4
JUL1	1.00000	0.97645	0.70402	0.90654	0.92377	0.88128	0.76304	0.90450
JUL2	0.97645	1.00000	0.71247	0.86110	0.87623	0.87285	0.75067	0.85926
JUL3	0.70402	0.71247	1.00000	0.69984	0.64382	0.60145	0.85435	0.71548
JUL4	0.90654	0.86110	0.69984	1.00000	0.80781	0.73270	0.72853	0.83294

Table K.11

CORRELATION COEFFICIENTS
BETWEEN MONTHLY FLOWS
1 = BIG WOOD, 2 = BIG LOST, 3 = GOOSE CREEK, 4 = CAMAS CREEK

Variable	N	Mean	Std Dev	Sum	Minimum	Maximum
AUG1	28	8.722812	0.467579	244.238744	7.750184	9.565354
AUG2	28	8.487581	0.506017	237.652262	7.425954	9.257319
AUG3	28	5.084014	1.463737	142.352400	0	6.529419
AUG4	28	4.728708	0.617361	132.403813	3.998201	6.218600
LAG1AUG1	28	9.542739	0.680947	267.196699	8.140316	10.808353
LAG1AUG2	28	9.415818	0.667049	263.642901	7.971431	10.498002
LAG1AUG3	28	5.754848	0.954340	161.135754	2.975530	6.770789
LAG1AUG4	28	5.700640	1.135907	159.617921	4.021774	7.878913

	AUG1	AUG2	AUG3	AUG4	LAG1AUG1	LAG1AUG2	LAG1AUG3	LAG1AUG4
AUG1	1.00000	0.94958	0.50009	0.85154	0.96009	0.92108	0.69385	0.91067
AUG2	0.94958	1.00000	0.56408	0.81890	0.91230	0.91387	0.69040	0.85334
AUG3	0.50009	0.56408	1.00000	0.56737	0.40683	0.38525	0.79066	0.53904
AUG4	0.85154	0.81890	0.56737	1.00000	0.75952	0.70774	0.58593	0.88836

Table K.12
CORRELATION COEFFICIENTS
BETWEEN MONTHLY FLOWS
1 = BIG WOOD, 2 = BIG LOST, 3 = GOOSE CREEK, 4 = CAMAS CREEK

Variable	N	Mean	Std Dev	Sum	Minimum	Maximum
SEP1	28	8.491859	0.383942	237.772063	7.632401	9.020511
SEP2	28	8.076811	0.377828	226.150710	7.265430	8.515592
SEP3	28	5.040334	1.235115	141.129361	0	6.501290
SEP4	28	4.722519	0.482822	132.230529	4.010963	5.744924
LAG1SEP1	28	8.722812	0.467579	244.238744	7.750184	9.565354
LAG1SEP2	28	8.487581	0.506017	237.652262	7.425954	9.257319
LAG1SEP3	28	5.084014	1.463737	142.352400	0	6.529419
LAG1SEP4	28	4.728708	0.617361	132.403813	3.998201	6.218600

	SEP1	SEP2	SEP3	SEP4	LAG1SEP1	LAG1SEP2	LAG1SEP3	LAG1SEP4
SEP1	1.00000	0.91130	0.32763	0.78354	0.94913	0.86606	0.37759	0.79390
SEP2	0.91130	1.00000	0.28633	0.74881	0.84938	0.84353	0.26614	0.65733
SEP3	0.32763	0.28633	1.00000	0.34107	0.34087	0.34505	0.79003	0.44162
SEP4	0.78354	0.74881	0.34107	1.00000	0.68198	0.56610	0.13449	0.74094

APPENDIX L

SIMPLE STATISTICS FOR

DATA GENERATION

Table L.1

Mean and Standard Deviations for Transformed Months
(by Raw Data)

MONTH	MEAN (X) (Cfs-days)	STD (S) (Cfs-days)	CV (S/X)
OCT1	5432.93	1838.76	0.33845
OCT2	3502.32	1273.91	0.36373
OCT3	456.43	167.82	0.36768
OCT4	215.45	119.00	0.55234
NOV1	5033.25	1392.39	0.27664
NOV2	2887.99	591.49	0.20481
NOV3	642.21	147.51	0.22969
NOV4	378.23	267.66	0.70767
DEC1	4507.89	999.62	0.22175
DEC2	2554.11	441.24	0.17275
DEC3	660.96	182.05	0.27543
DEC4	620.92	438.30	0.70588
APR1	16876.00	8616.01	0.51055
APR2	6182.72	3318.33	0.53671
APR3	2935.94	1487.57	0.50668
APR4	32735.00	28691.00	0.87646
JUL1	17112.00	10901.00	0.63704
JUL2	14875.00	8815.17	0.59262
JUL3	418.23	234.96	0.56179
JUL4	562.54	696.64	1.23838
AUG1	6797.46	3085.64	0.45394
AUG2	5440.86	2508.85	0.46111
AUG3	262.35	170.50	0.64988
AUG4	140.34	113.89	0.81151
SEP1	5209.93	1842.35	0.35362
SEP2	3427.68	1137.48	0.33185
SEP3	222.53	140.74	0.63246
SEP4	126.93	69.80	0.54993

* " 1 " = Big Wood River, " 2 " = Big Lost River,
" 3 " = Goose Creek, " 4 " = Camas Creek

Table L.2

Means and Standard Deviations for Transformed Months
(by Chow's Equations)

MONTH	MEAN (Y)	STD (S)
OCT1	8.5460	0.329314
OCT2	8.0991	0.352495
OCT3	6.0600	0.356085
OCT4	5.2396	0.516011
NOV1	8.4870	0.271554
NOV2	7.9478	0.202710
NOV3	6.4392	0.226742
NOV4	5.7325	0.637182
DEC1	8.3896	0.219093
DEC2	7.8308	0.171486
DEC3	6.4571	0.270412
DEC4	6.2291	0.635855
APR1	9.6178	0.481284
APR2	8.6029	0.503126
APR3	7.8705	0.478024
APR4	10.1112	0.754953
JUL1	9.5772	0.583626
JUL2	9.4569	0.548624
JUL3	5.8989	0.523738
JUL4	5.8677	0.964175
AUG1	8.7306	0.432851
AUG2	8.5053	0.439076
AUG3	5.3935	0.593556
AUG4	4.6911	0.711294
SEP1	8.4994	0.343259
SEP2	8.0874	0.323224
SEP3	5.2368	0.580070
SEP4	4.7115	0.514033

* " 1 " = Big Wood River, " 2 " = Big Lost River, " 3 " = Goose Creek, " 4 " = Camas Creek

* Streamflows are in cfs-days

Table L.3

Coefficients of Skew for Historical and Generated Monthly Streamflows
Station: 13.1415.00
(Period: 1925 - 1952 Water Years)

Month	Skew Coeff (Historical)	Skew Coeff (Generated)
October	0.8896	0.5398
November	1.1810	1.9514
December	1.3869	0.6367
January	0.1997	0.0988
Feburary	3.5363	0.2750
March	1.6143	1.4948
April	1.1358	2.1315
May	1.4835	0.7880
June	0.8445	0.5808
July	1.9066	3.1242
August	2.1844	1.7335
September	1.4223	4.8012

Table L.4

Correlation Coefficients between
Historical Monthly Flows
and Generated Monthly Flows
for Camas Creek
(Period: 1925 - 1952 Water Years)

Month	Corr. Coeff.
October	0.79080
November	0.78952
December	0.41585
January	0.78296
Feburary	0.29251
March	0.83049
April	0.71047
May	0.89370
June	0.84475
July	0.69785
August	0.68705
September	0.54754

Fig. L.1

CAMAS CREEK OCTOBER STREAMFLOWS

(OBSERVED VS. GENERATED)

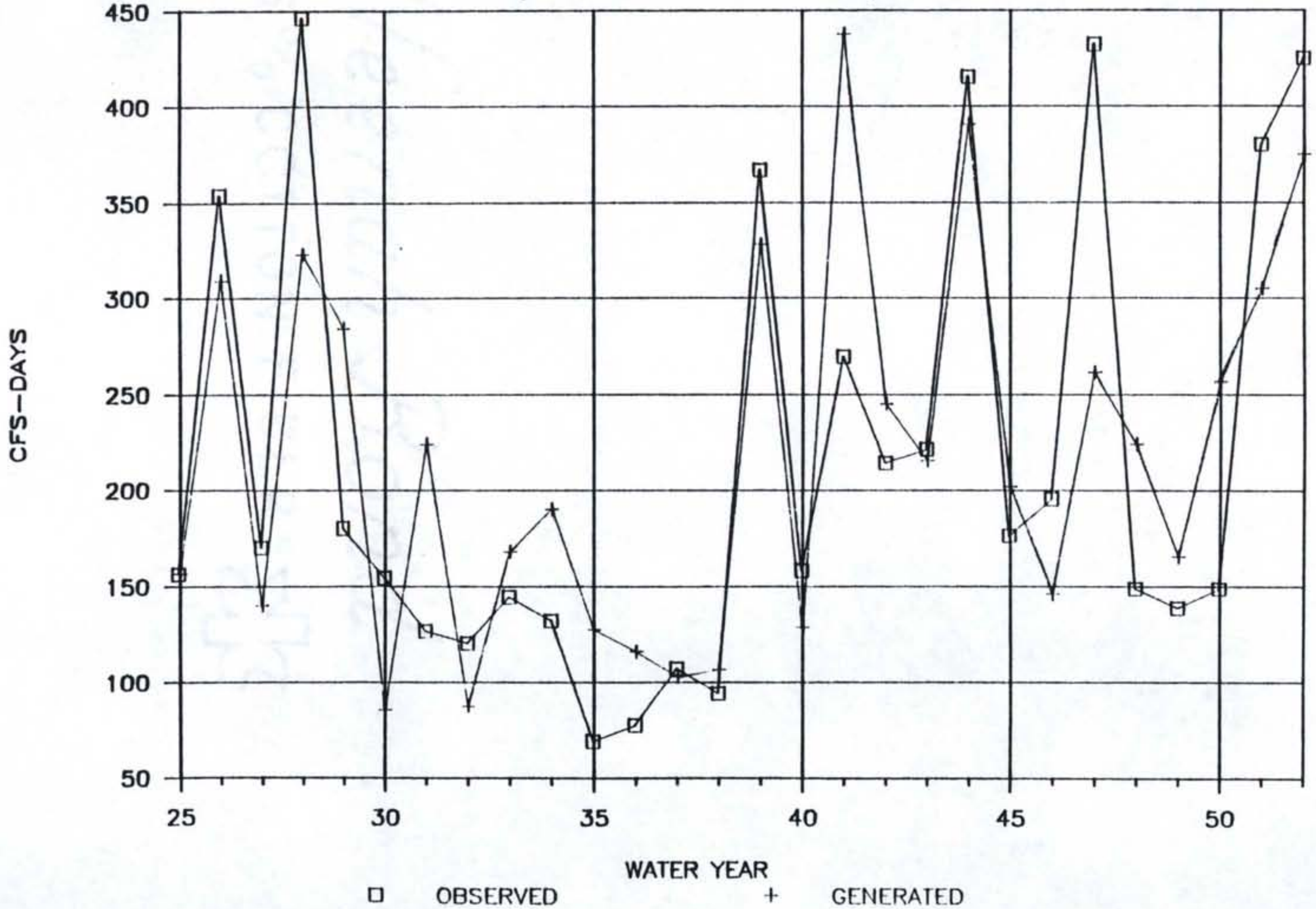
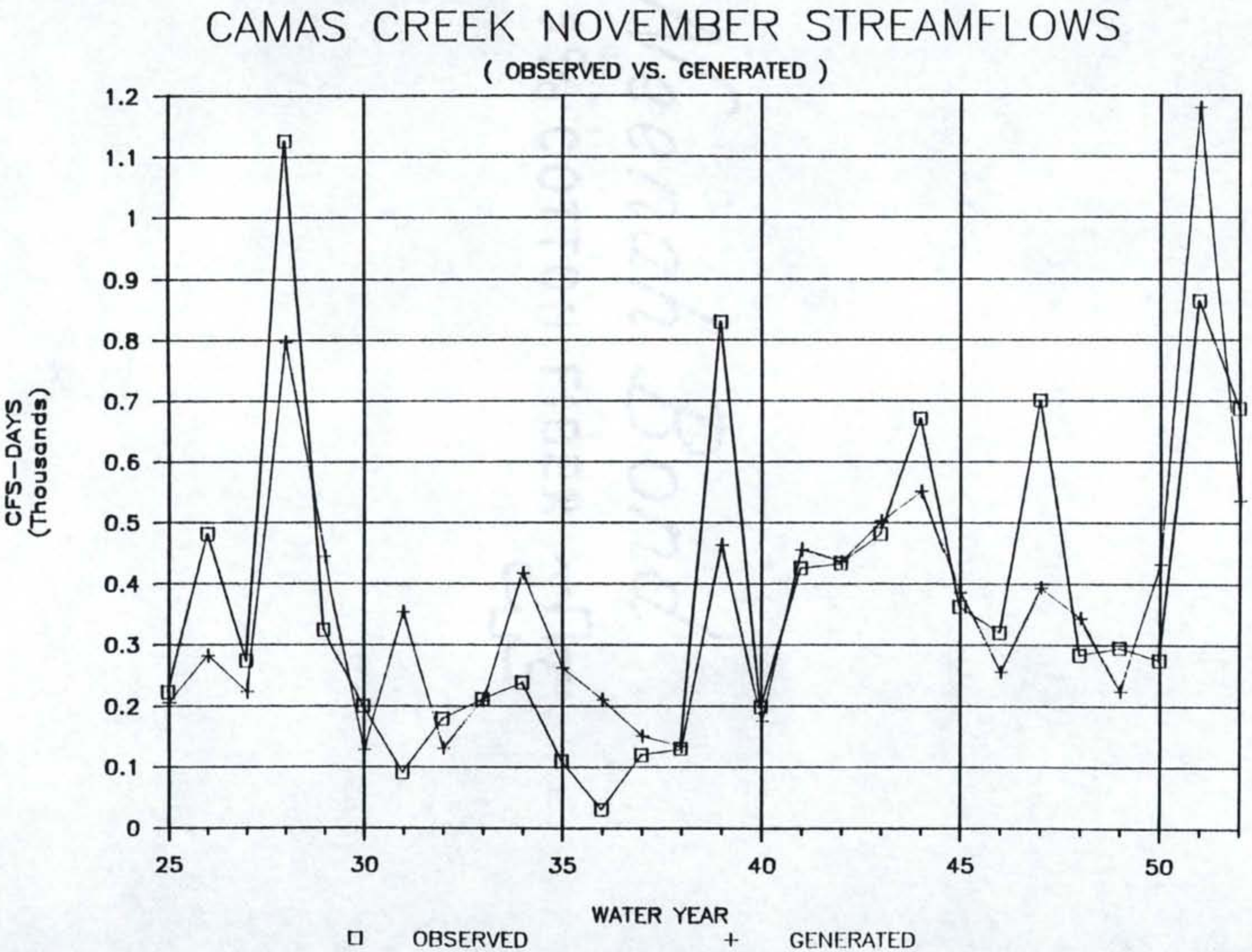


Fig. L.2



CAMAS CREEK NOVEMBER STREAMFLOWS
(OBSERVED VS. GENERATED)
CFS—DAYS
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
25
30
35
40
45
50
WATER YEAR
OBSERVED
GENERATED

Fig. L.3

CAMAS CREEK DECEMBER STREAMFLOWS

(OBSERVED VS. GENERATED)

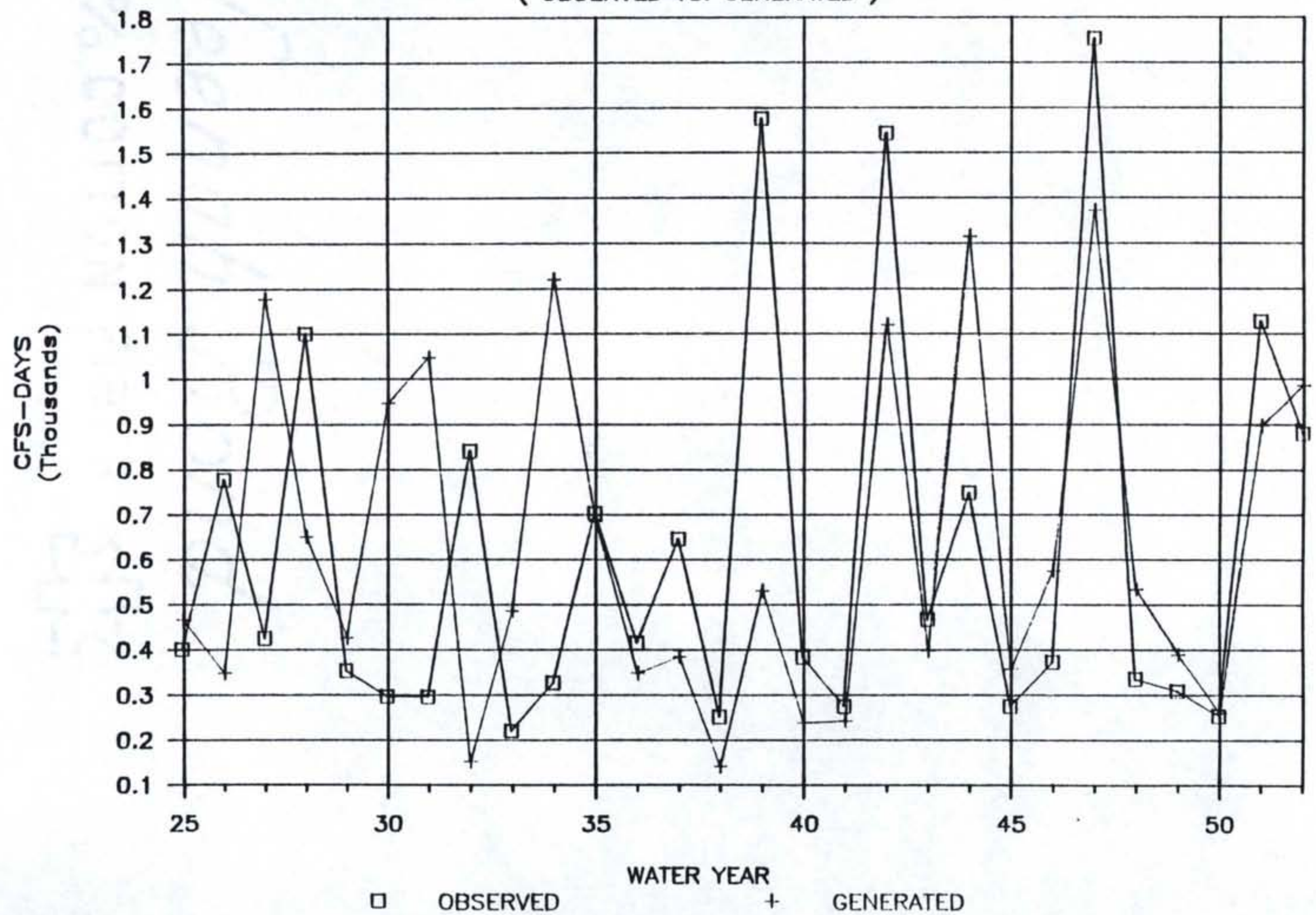


Fig. L.4

CAMAS CREEK JANUARY STREAMFLOWS

(OBSERVED VS. GENERATED)

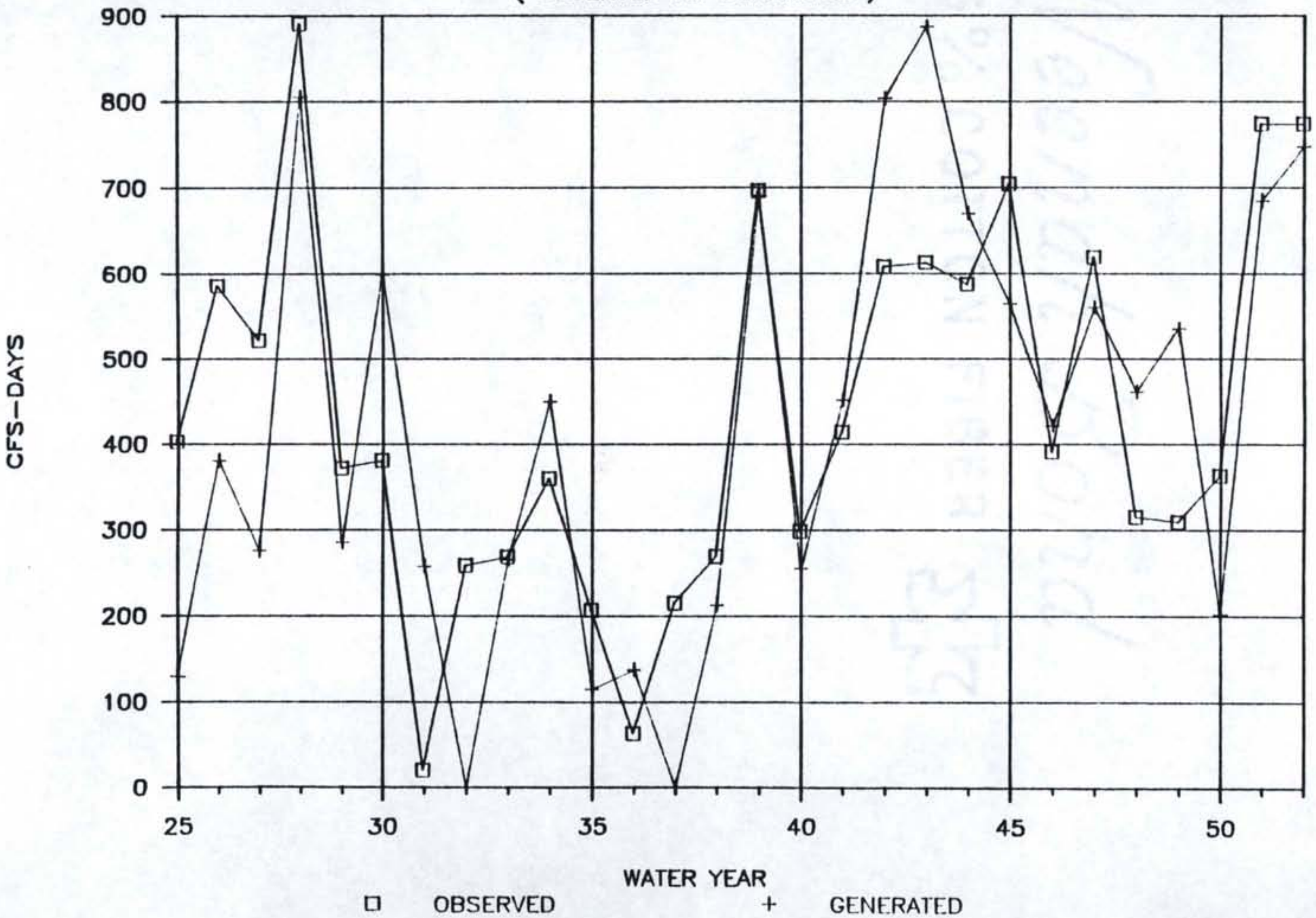
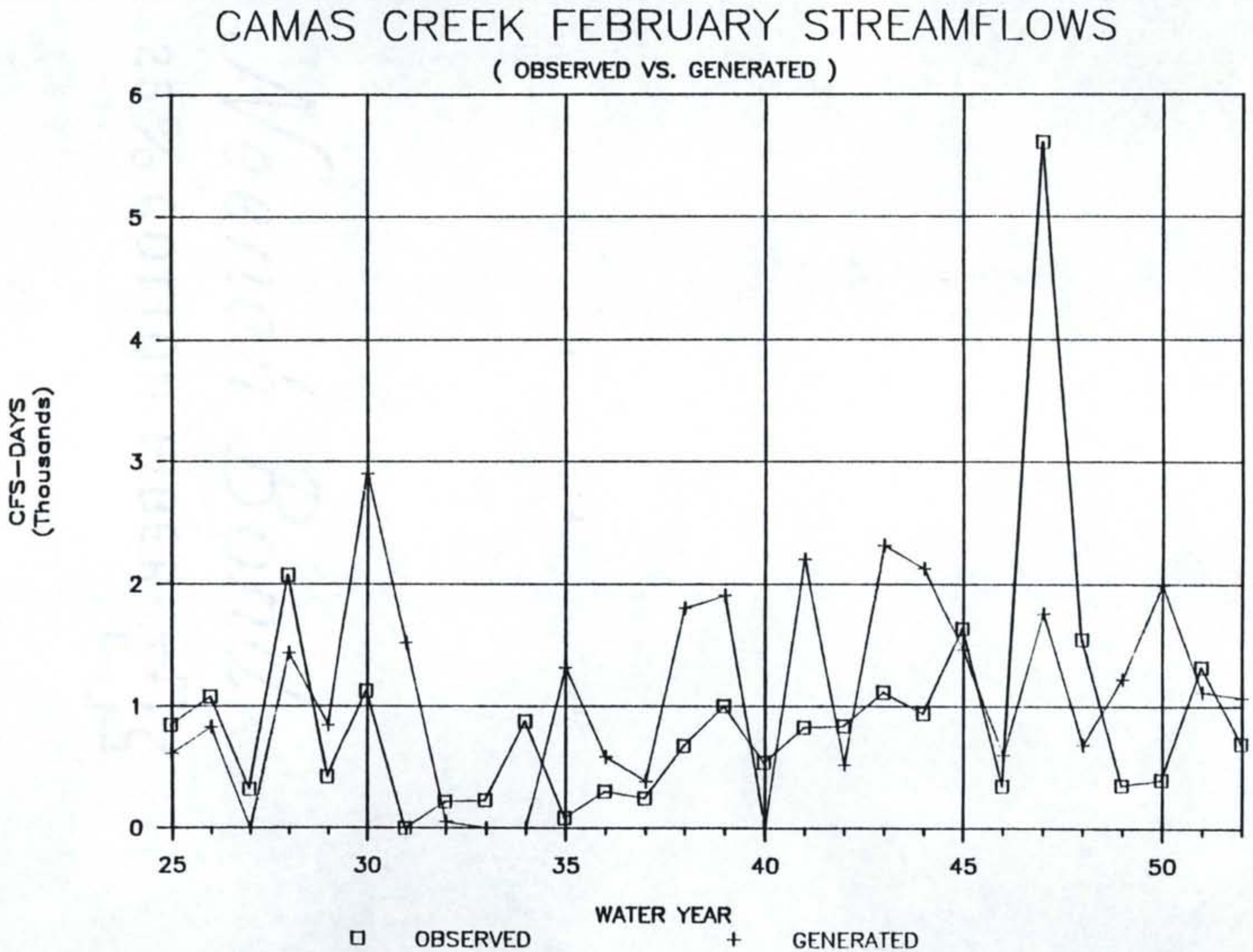
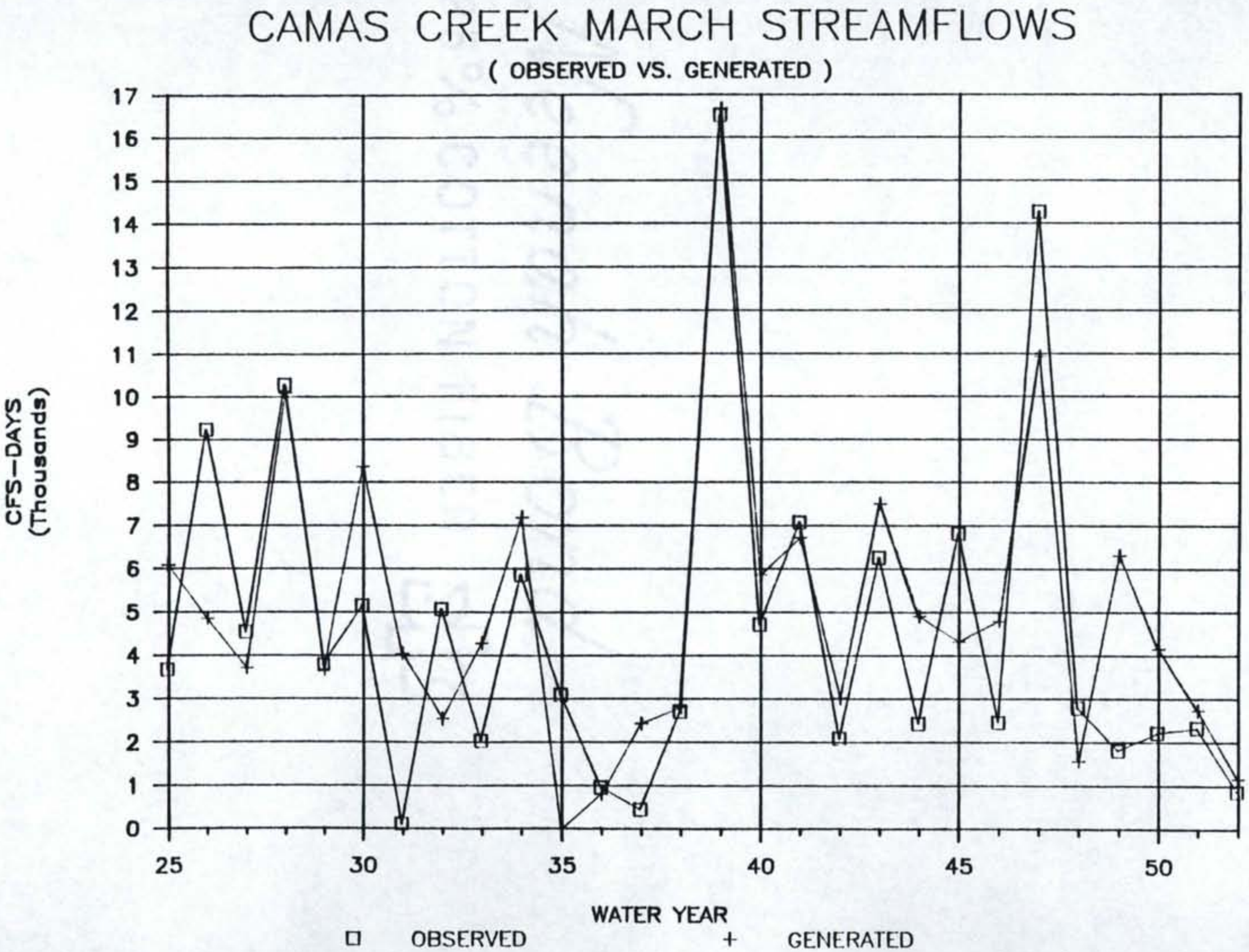


Fig. L.5



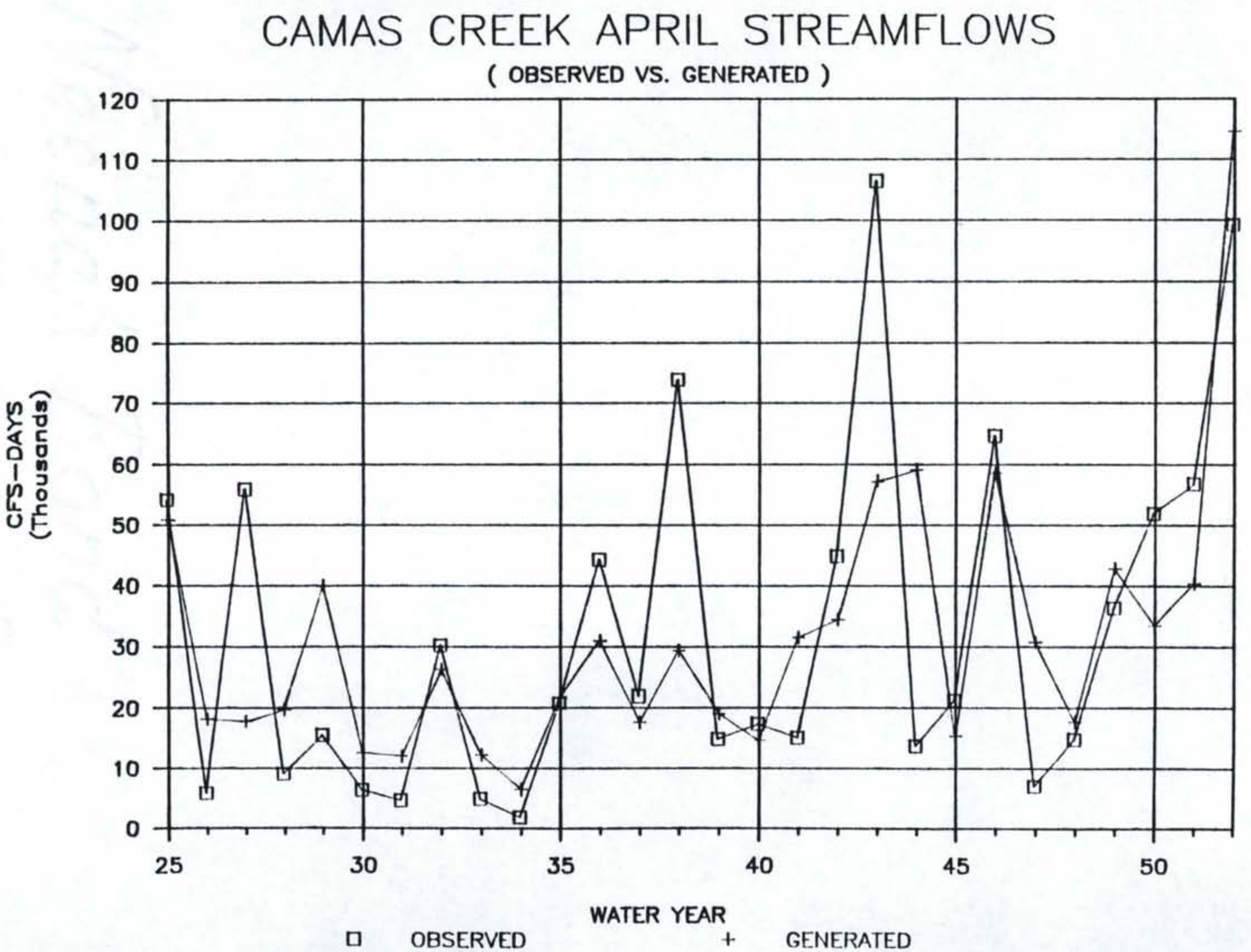
CAMAS CREEK FEBRUARY STREAMFLOWS
(OBSERVED VS. GENERATED)
6
5
4
3
2
1
0
CFS—DAYS
(Thousands)
25
30
35
40
45
50
WATER YEAR
OBSERVED
GENERATED

Fig. L.6



CAMAS CREEK MARCH STREAMFLOWS
(OBSERVED VS. GENERATED)
CFS-DAYS
(Thousands)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
25
30
35
40
45
50
WATER YEAR
OBSERVED
+ GENERATED

Fig. L.7



CAMAS CREEK APRIL STREAMFLOWS
(OBSERVED VS. GENERATED)
CFS—DAYS
(Thousands)
0
10
20
30
40
50
60
70
80
90
100
110
120
25
30
35
40
45
50
WATER YEAR
OBSERVED
GENERATED

Fig. L.8

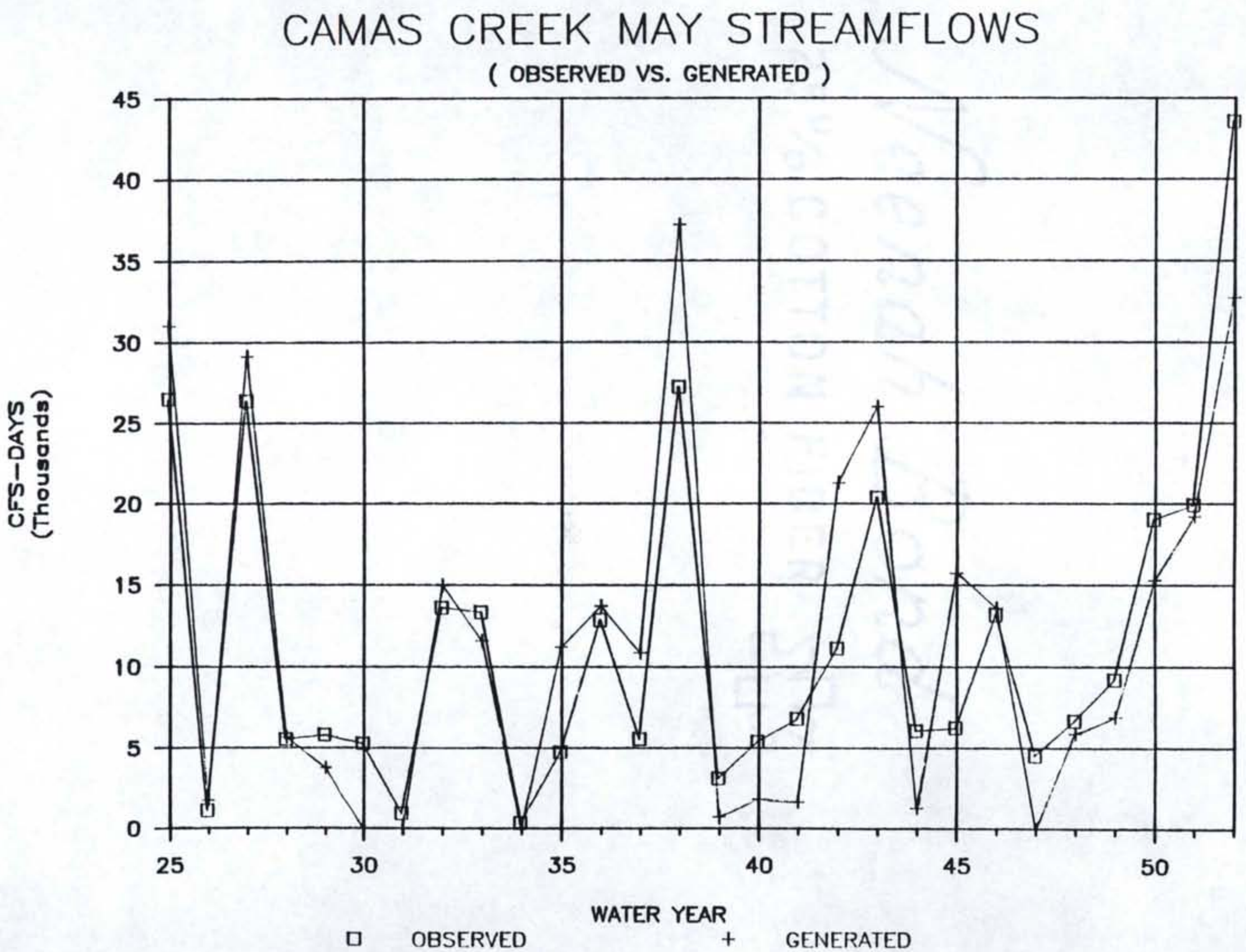

CAMAS CREEK MAY STREAMFLOWS
(OBSERVED VS. GENERATED)
CFS—DAYS
(Thousands)
45
40
35
30
25
20
15
10
5
0
25
30
35
40
45
50
WATER YEAR
OBSERVED
+ GENERATED

Fig. L.9

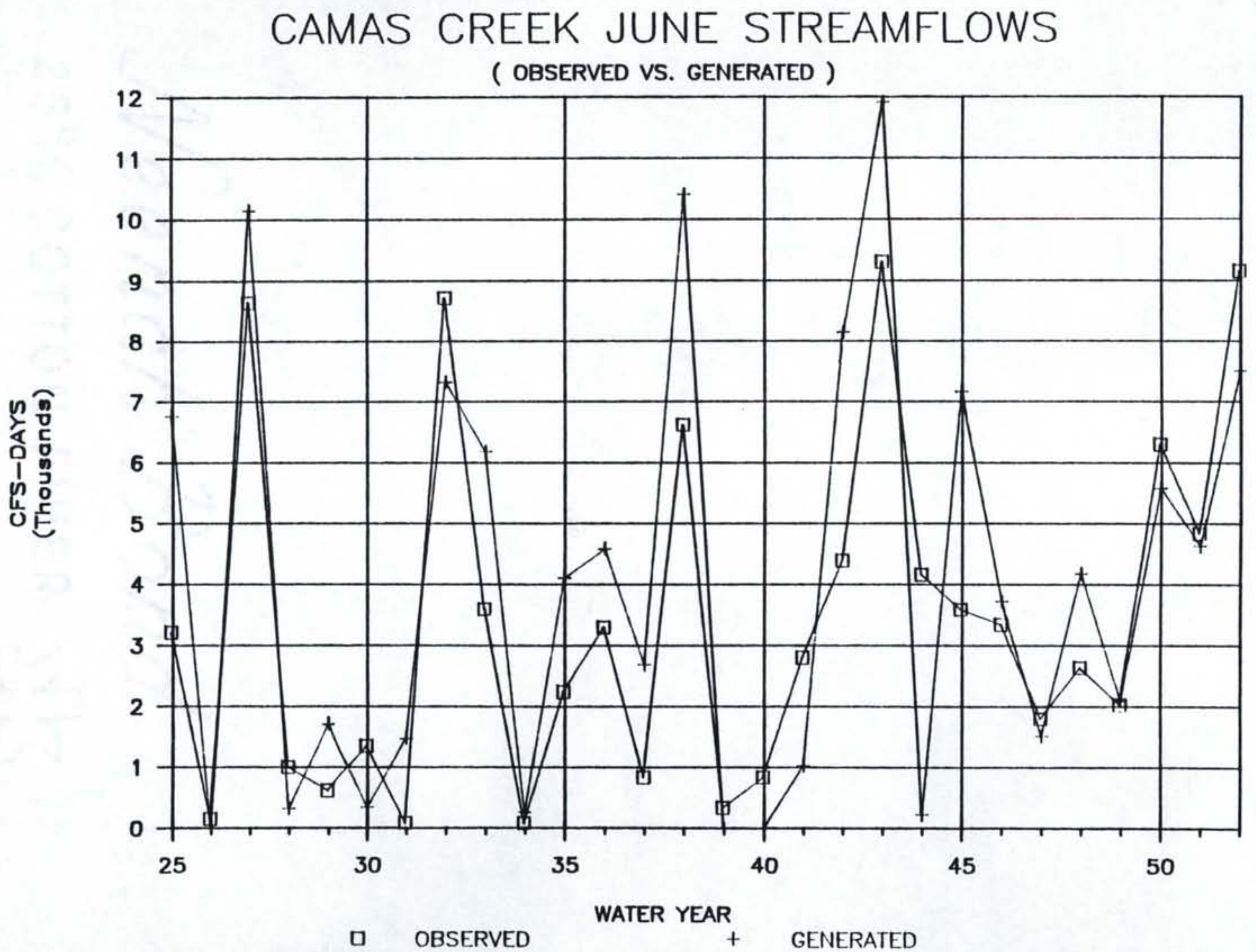
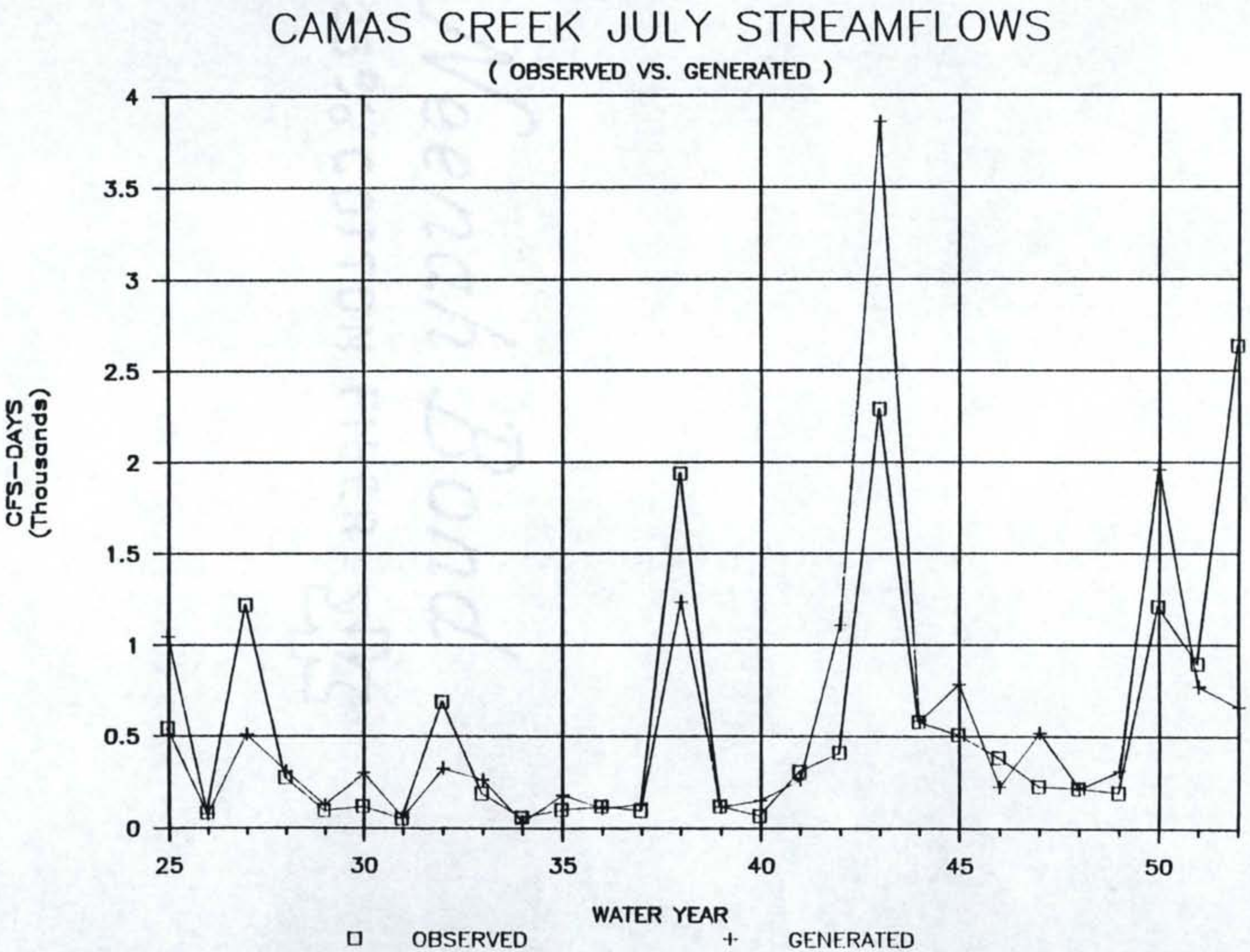

CAMAS CREEK JUNE STREAMFLOWS
(OBSERVED VS. GENERATED)
CFS—DAYS
(Thousands)
0
1
2
3
4
5
6
7
8
9
10
11
12
25
30
35
40
45
50
WATER YEAR
OBSERVED
GENERATED

Fig. L.10



CAMAS CREEK JULY STREAMFLOWS
(OBSERVED VS. GENERATED)
CFS–DAYS
(Thousands)
0
0.5
1
1.5
2
2.5
3
3.5
4
25
30
35
40
45
50
WATER YEAR
OBSERVED
GENERATED

Fig. L.11

CAMAS CREEK AUGUST STREAMFLOWS

(OBSERVED VS. GENERATED)

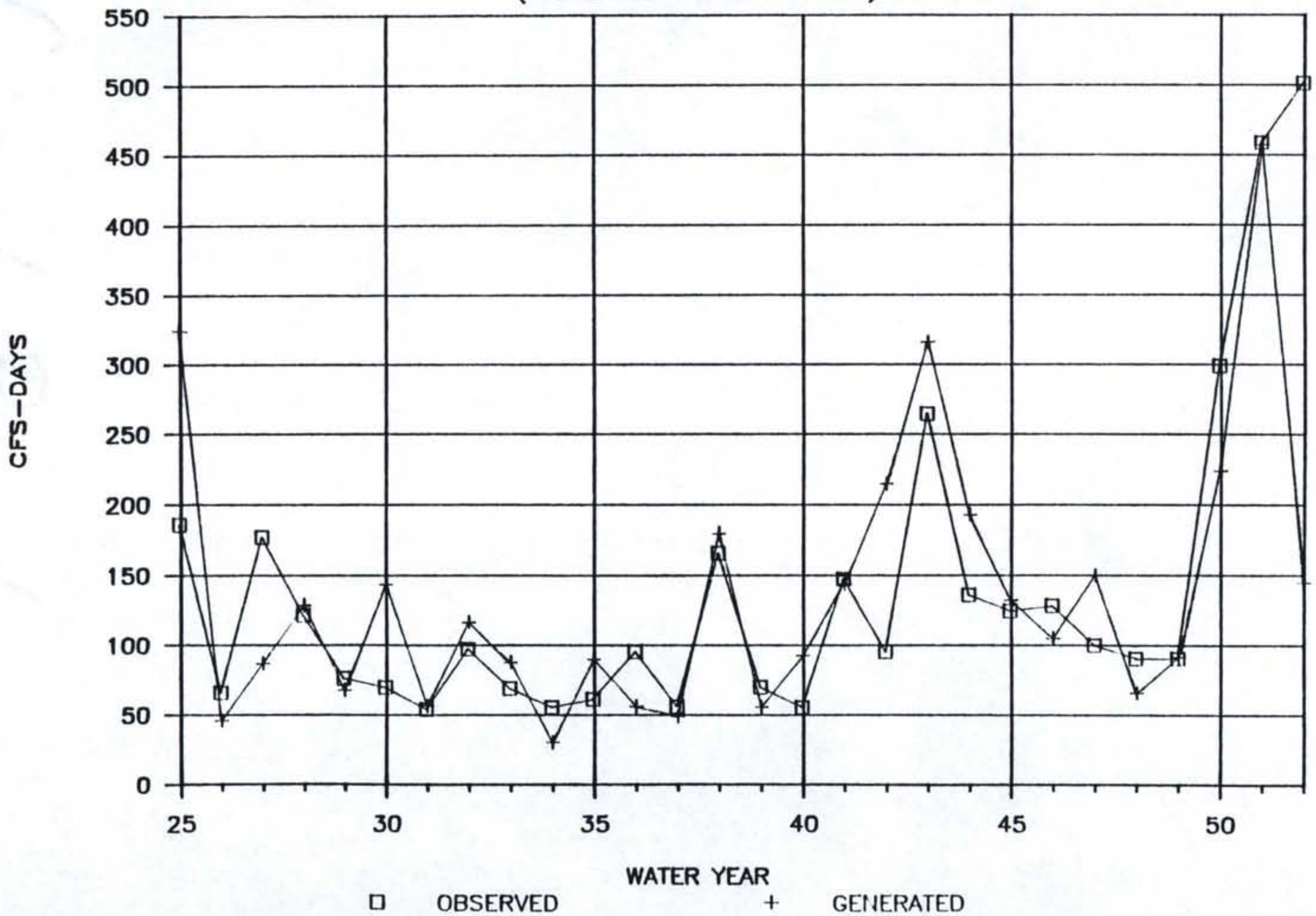


Fig. L.12

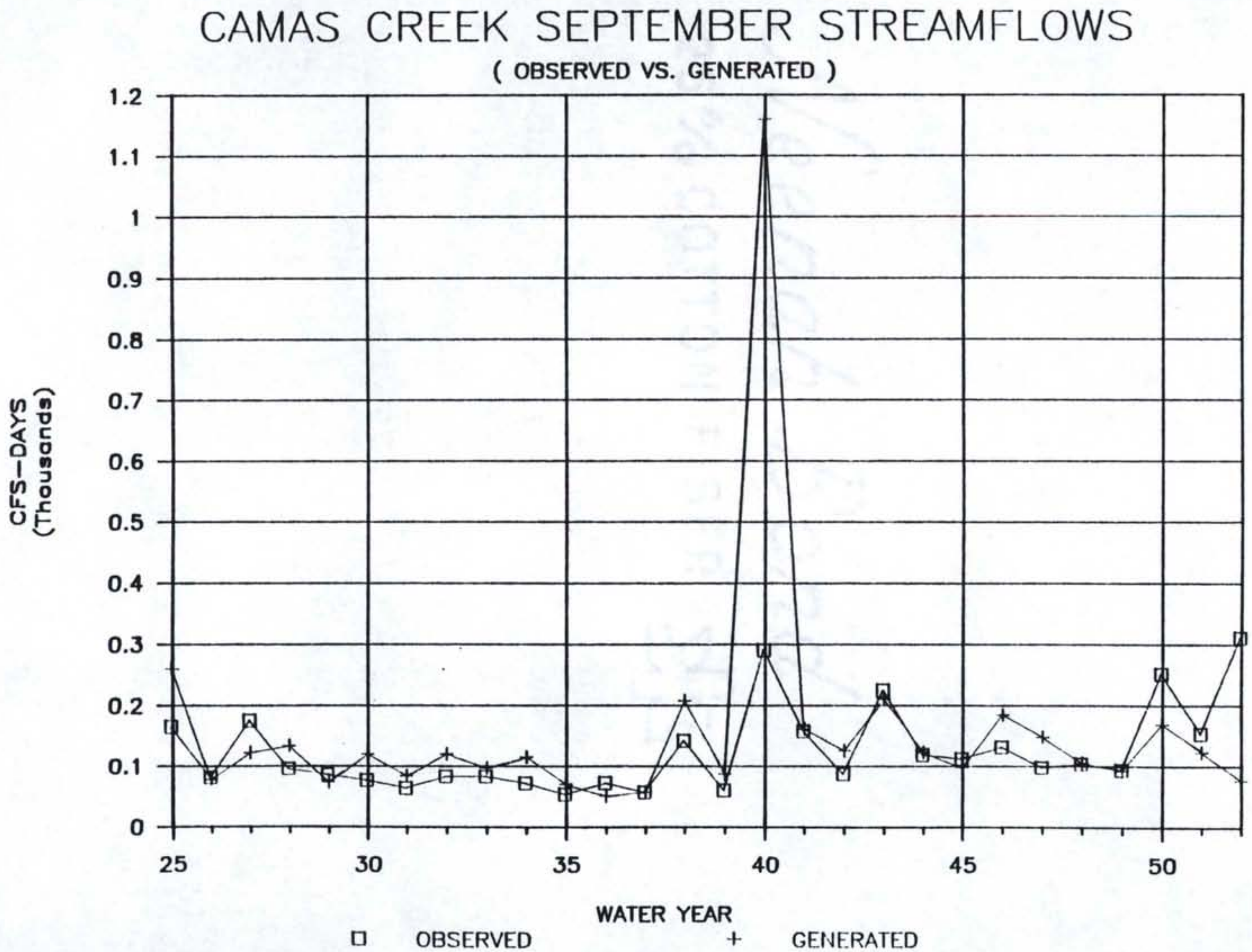
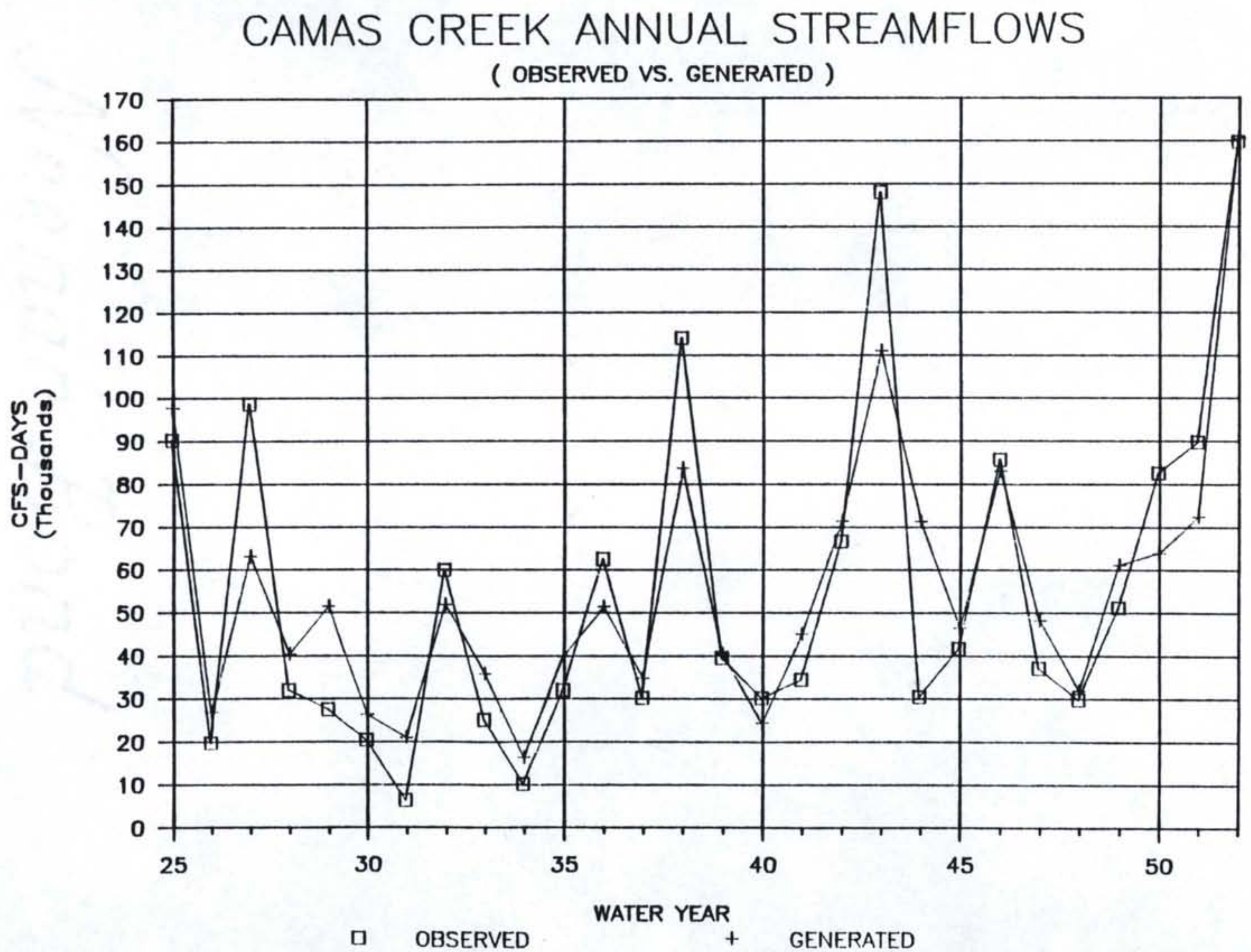

CAMAS CREEK SEPTEMBER STREAMFLOWS
(OBSERVED VS. GENERATED)
CFS-DAYS
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
25
30
35
40
45
50
WATER YEAR
OBSERVED
GENERATED

Fig. L.13


CAMAS CREEK ANNUAL STREAMFLOWS
(OBSERVED VS. GENERATED)
CFS-DAYS
(Thousands)
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
25
30
35
40
45
50
WATER YEAR
OBSERVED
GENERATED

APPENDIX M

COMPARISONS OF MONTHLY FLOW STATISTICS BETWEEN DRY AND WET PERIODS

Table M.1

Ratios of Monthly Statistics between
Dry and Wet Period Flows (cfs-days)
Station: 13.1395.10

Month	Mean Dry	Mean Wet	Ratio Wet/Dry	Std. Dev. Dry	Std. Dev. Wet	Ratio Wet/Dry
Oct	5432	7217	1.33	1838	1900	1.03
Nov	5033	6319	1.26	1392	1581	1.14
Dec	4507	5575	1.24	999	1165	1.17
Jan	4211	5400	1.28	877	1039	1.18
Feb	3845	4749	1.24	696	807	1.16
Mar	5205	6011	1.15	1518	1492	0.98
Apr	16875	15752	0.93	8616	7940	0.92
May	38269	43272	1.13	18018	22185	1.23
Jun	37074	50464	1.36	19540	24252	1.24
Jul	17112	23550	1.38	10900	13109	1.20
Aug	6797	9706	1.43	3085	4202	1.36
Sep	5209	7387	1.42	1842	2583	1.40

* " Dry " indicates the period of 1925-1952 water years
* " Wet " indicates the period of 1953-1985 water years

Table M.2

Ratios of Monthly Statistics between
Dry and Wet Period Flows (cfs-days)
Station: 13.1205.00

Month	Mean Dry	Mean Wet	Ratio Wet/Dry	Std. Dev. Dry	Std. Dev. Wet	Ratio Wet/Dry
Oct	3502	4607	1.32	1273	1237	0.97
Nov	2887	3385	1.17	591	1595	2.70
Dec	2554	2905	1.14	441	1172	2.66
Jan	2340	2721	1.16	385	1033	2.68
Feb	2026	2312	1.14	302	810	2.68
Mar	2312	2551	1.10	393	789	2.01
Apr	6182	5301	0.86	3318	2744	0.83
May	23454	25990	1.11	8658	11827	1.37
Jun	29925	41299	1.38	13606	15206	1.12
Jul	14875	20747	1.39	8815	11508	1.31
Aug	5440	7475	1.37	2508	3583	1.43
Sep	3427	4972	1.45	1137	2164	1.90

* " Dry " indicates the period of 1925-1952 water years
* " Wet " indicates the period of 1953-1985 water years

Table M.3

Ratios of Monthly Statistics between
Dry and Wet Period Flows (cfs-days)
Station: 13.0825.00

Month	Mean Dry	Mean Wet	Ratio Wet/Dry	Std. Dev. Dry	Std. Dev. Wet	Ratio Wet/Dry
Oct	456	614	1.35	167	234	1.40
Nov	642	766	1.19	147	224	1.52
Dec	660	803	1.22	182	255	1.40
Jan	723	1149	1.59	366	920	2.51
Feb	1045	1493	1.43	815	1131	1.39
Mar	1723	2044	1.19	774	906	1.17
Apr	2935	2972	1.01	1487	1353	0.91
May	3902	4923	1.26	2212	3760	1.70
Jun	1547	2299	1.49	940	2281	2.43
Jul	418	615	1.47	234	538	2.30
Aug	262	435	1.66	170	313	1.84
Sep	222	398	1.79	140	231	1.65

* " Dry " indicates the period of 1925-1952 water years
* " Wet " indicates the period of 1953-1985 water years

Table M.4

Process to Estimate " Natural " Monthly
Mean of October
Camas Creek Station

1. Calculate Ratio of the Mean of Wet and Dry Periods for Three Subordinate Stations

   (1) Big Wood Slough (13.1395.10)
   Ratio = 7217/5432 = 1.33
   (2) Big Lost River (13.1205.00)
   Ratio = 3502/4607 = 1.32
   (3) Goose Creek (13.0825.00)
   Ratio = 614/456 = 1.35

2. Calculate Coefficients of Determination between Camas Creek and Three Subordinate Stations

   (1) Coefficient of Determination between Camas Creek and Big Wood Slough = 0.72
   (2) Coefficient of Determination between Camas Creek and Big Lost River = 0.53
   (3) Coefficient of Determination between Camas Creek and Goose Creek = 0.24
   (4) Total = (1)+(2)+(3) = 1.49

3. Calculate Weighted Average Ratio

   Weighted Average Ratio = 1.33(0.72/1.49) +1.32(0.53/1.49) +1.35(0.24/1.49)
   = 1.33

4. Estimate the " Natural " Monthly Mean Flows

   Estimated Mean Flows = Dry Period Mean x Weighted Average Ratio
   = 215 x 1.33
   = 285.95

Table M.5

Estimation of Monthly Statistics for
Wet Period Using Weighted Average Ratios
Station: 13.1415.00

Month	Mean Dry	Ratio Wet/Dry	Mean Wet	S.Dev. Dry	Ratio Wet/Dry	S.Dev. Wet
Oct	215	1.33	285.95	119	1.08	128.52
Nov	378	1.21	457.38	267	1.72	459.24
Dec	620	1.19	737.80	438	1.90	832.20
Jan	439	1.28	561.92	218	1.70	370.60
Feb	920	1.25	1150.00	1048	1.44	1509.12
Mar	4641	1.15	5337.15	3950	1.33	5253.50
Apr	32734	0.97	31751.98	28690	0.90	25821.00
May	11630	1.17	13607.10	10069	1.41	14197.29
Jun	3440	1.40	4816.00	2891	1.52	4394.32
Jul	562	1.41	792.42	696	1.50	1044.00
Aug	140	1.45	203.00	113	1.47	166.11
Sep	126	1.47	185.22	69	1.63	112.47

* Streamflows are in cfs-days
* " Dry " indicates the period of 1925-1952 water years
* " Wet " indicates the period of 1953-1985 water years

APPENDIX N

COMPARISONS BETWEEN HISTORICAL FLOWS AND GENERATED FLOWS

(All units are in cfs-days)

TABLE N.1

HISTORICAL MONTHLY FLOWS OF THE KEY STATION AND THREE SUBORDINATE STATIONS
VS.
GENERATED MONTHLY FLOWS OF THE KEY STATION

WYEAR	OCT1	OCT2	OCT3	OCT4	OCT4G
53	6923.00	3306	559.0	400.0	400.000
54	6261.00	3214	518.0	229.7	154.499
55	5529.00	2528	439.0	181.0	215.726
56	4344.00	2403	426.0	141.5	117.133
57	7557.00	3321	422.5	294.8	392.107
58	6537.00	4167	490.3	245.1	152.555
59	6417.00	3402	475.0	312.7	238.744
60	7491.00	3840	626.0	285.3	340.070
61	4024.00	2084	413.9	139.9	110.920
62	4838.00	3055	521.0	142.9	229.910
63	6914.00	3890	429.0	245.5	225.753
64	6461.00	4031	400.0	256.5	248.380
65	5685.00	3055	440.4	238.0	154.354
66	9744.00	5262	633.0	1251.0	487.384
67	4591.00	2485	329.2	173.1	144.220
68	8995.00	6226	426.6	338.0	248.290
69	6949.00	5029	500.0	255.9	193.136
70	7942.00	4239	442.9	403.7	280.073
71	7720.00	4025	609.0	477.1	288.699
72	10156.00	5401	732.0	846.0	442.136
73	8575.00	4785	966.0	703.0	546.277
74	6010.28	3073	834.0	207.0	203.099
75	7938.55	3428	668.0	272.6	260.258
76	8140.92	4888	1052.0	406.4	322.562
77	7923.47	5108	889.0	387.0	337.682
78	5165.32	2761	563.0	96.5	251.547
79	7203.08	5175	624.0	253.1	332.225
80	5303.95	2759	532.0	178.2	195.795
81	8381.32	4543	698.0	325.2	274.043
82	6795.34	3859	427.4	137.3	266.261
83	9312.85	6014	860.0	613.0	406.978
84	13048.78	6927	903.0	1230.0	450.301
85	9314.88	5960	1416.0	880.0	310.482

* "OCT1" indicates historical October flows of the Big Wood River
* "OCT2" indicates historical October flows of the Big Lost River
* "OCT3" indicates historical October flows of the Goose Creek
* "OCT4" indicates historical October flows of the Camas Creek
* "OCT4G" indicates generated October flows of the Camas Creek

TABLE N.2

HISTORICAL MONTHLY FLOWS OF THE KEY STATION AND THREE SUBORDINATE STATIONS
VS.
GENERATED MONTHLY FLOWS OF THE KEY STATION

WYEAR	NOV1	NOV2	NOV3	NOV4	NOV4G
53	5809.00	2673	631.0	744.0	473.20
54	5484.00	2824	669.0	388.6	105.41
55	4887.00	2169	583.0	330.4	150.42
56	4779.00	1952	625.0	252.3	171.83
57	6193.00	2671	589.0	441.0	413.44
58	5776.00	3035	678.0	336.0	138.60
59	6238.00	2853	675.0	402.5	630.24
60	5549.00	2697	565.0	307.4	458.62
61	3827.00	1944	633.0	232.5	73.20
62	4269.00	2435	626.0	163.9	181.77
63	5477.00	2917	596.0	389.3	310.60
64	6430.00	3568	687.0	625.0	537.50
65	5229.00	2529	672.0	385.0	154.08
66	7877.00	4019	742.6	1535.0	1553.97
67	4738.00	2227	525.0	398.1	164.90
68	7465.00	3857	457.0	538.0	426.72
69	5973.00	3734	743.0	467.9	262.50
70	5956.00	261	533.0	602.0	317.13
71	7890.00	3196	813.0	1560.0	1389.58
72	7899.00	4402	944.0	1328.0	685.97
73	6886.00	3373	1141.0	1052.0	945.08
74	6820.46	3466	1087.0	969.0	428.94
75	7011.88	3004	869.0	590.0	363.76
76	7168.31	3785	1133.0	789.0	806.33
77	6107.50	3476	946.0	461.0	351.13
78	4604.08	1821	703.0	200.3	186.76
79	6019.22	3980	700.0	331.8	398.98
80	4796.99	2451	716.0	257.7	134.92
81	6827.05	3798	847.0	447.0	264.48
82	6288.24	3190	668.0	371.2	176.58
83	7619.31	4183	955.0	1039.0	481.49
84	12423.81	11196	1003.0	2480.0	2096.43
85	8213.21	5034	1527.0	1595.0	921.94

* "NOV1" indicates historical November flows of the Big Wood River
* "NOV2" indicates historical November flows of the Big Lost River
* "NOV3" indicates historical November flows of the Goose Creek
* "NOV4" indicates historical November flows of the Camas Creek
* "NOV4G" indicates generated November flows of the Camas Creek

TABLE N.3

HISTORICAL MONTHLY FLOWS OF THE KEY STATION AND THREE SUBORDINATE STATIONS
VS.
GENERATED MONTHLY FLOWS OF THE KEY STATION

WYEAR	DEC1	DEC2	DEC3	DEC4	DEC4G
53	6177.00	2720	694.0	776.0	850.72
54	4731.00	2211	639.0	665.0	102.32
55	4194.00	1760	491.5	351.3	836.52
56	6776.00	2823	997.0	2058.2	190.25
57	5421.00	2188	834.3	1760.0	518.93
58	5579.00	2566	749.0	445.0	1229.59
59	5691.00	2308	827.0	848.0	1247.95
60	4499.00	2171	467.0	394.0	279.35
61	3600.00	1809	546.0	300.8	216.61
62	3590.00	1782	688.0	269.2	746.05
63	4820.00	2419	583.0	680.0	373.69
64	4997.00	2945	440.7	589.0	456.46
65	6716.00	2906	1403.0	13990.0	232.21
66	6048.00	3230	632.2	1273.0	419.32
67	4416.00	2148	425.5	408.0	216.77
68	6234.00	2893	366.6	499.0	251.48
69	4986.00	3166	749.0	459.0	193.55
70	5377.00	2948	592.0	674.0	1119.62
71	6454.00	2818	942.0	1769.0	735.79
72	6235.00	3106	992.0	1223.0	3002.66
73	5089.00	2792	1172.0	926.0	1014.91
74	5739.06	2600	891.0	959.0	549.33
75	5664.87	3002	704.0	620.0	1472.39
76	6321.85	3262	1308.0	1143.0	1503.70
77	5344.28	2615	863.0	478.0	474.75
78	4643.38	2271	932.0	596.9	248.08
79	4984.62	3261	722.0	422.0	265.24
80	4576.83	2176	772.0	273.0	418.84
81	6104.47	3300	981.0	787.0	915.10
82	5391.64	3068	928.0	811.0	79.61
83	6575.48	3461	920.0	968.0	1145.57
84	9637.41	8612	1165.0	1618.0	9170.90
85	7391.99	4555	1084.0	1147.0	881.98

* "DEC1" indicates historical December flows of the Big Wood River
* "DEC2" indicates historical December flows of the Big Lost River
* "DEC3" indicates historical December flows of the Goose Creek
* "DEC4" indicates historical December flows of the Camas Creek
* "DEC4G" indicates generated December flows of the Camas Creek

TABLE N.4

HISTORICAL MONTHLY FLOWS OF THE KEY STATION AND THREE SUBORDINATE STATIONS
VS.
GENERATED MONTHLY FLOWS OF THE KEY STATION

WYEAR	JAN1	JAN2	JAN3	JAN4	JAN4G
53	6474.00	2835	1173.0	1313.0	626.64
54	4949.00	2063	694.0	594.0	0.0
55	4076.00	1642	512.0	411.0	244.80
56	5808.00	1990	1370.0	3076.0	861.97
57	4706.00	1945	559.0	558.0	530.05
58	5083.00	2469	719.0	618.0	753.48
59	5124.00	2068	853.0	747.0	640.22
60	4372.00	2271	502.0	467.0	100.50
61	3775.00	1583	597.0	290.3	0.0
62	3713.00	1683	2128.0	634.0	209.48
63	4196.00	2035	353.6	509.0	303.74
64	4581.00	2790	458.0	527.0	485.04
65	7150.00	3416	2435.0	7640.0	239.62
66	6198.00	3177	687.0	1288.0	485.12
67	4757.00	2232	678.0	674.0	322.50
68	5485.00	2653	471.0	569.0	774.89
69	5169.00	3138	997.0	916.0	339.17
70	5308.00	2725	2484.0	794.0	1041.15
71	6019.00	3110	5043.0	1841.0	1528.91
72	6627.00	3162	1412.0	1160.0	912.97
73	5073.00	2302	1059.0	1017.0	652.08
74	6108.39	3931	780.0	1003.0	374.50
75	5533.86	3097	902.5	617.0	695.88
76	5701.01	2699	915.0	845.0	864.63
77	5120.43	2284	847.0	473.0	656.92
78	4513.59	2573	1041.0	521.0	0.0
79	4805.35	2749	693.0	363.6	490.99
80	4912.05	2184	2761.0	439.8	571.87
81	5818.46	2737	857.0	834.0	978.84
82	5166.99	2614	782.0	650.0	214.46
83	6210.31	2655	897.0	1175.0	977.53
84	8533.27	7586	1244.0	2032.0	1167.77
85	7133.91	3410	1018.0	1114.0	984.49

* "JAN1" indicates historical January flows of the Big Wood River
* "JAN2" indicates historical January flows of the Big Lost River
* "JAN3" indicates historical January flows of the Goose Creek
* "JAN4" indicates historical January flows of the Camas Creek
* "JAN4G" indicates generated January flows of the Camas Creek

TABLE N.5

HISTORICAL MONTHLY FLOWS OF THE KEY STATION AND THREE SUBORDINATE STATIONS
VS.
GENERATED MONTHLY FLOWS OF THE KEY STATION

WYEAR	FEB1	FEB2	FEB3	FEB4	FEB4G
53	4804.00	2300	924	1971.0	399.68
54	4486.00	2006	926	903.0	144.57
55	3560.00	1454	556	383.0	612.81
56	4217.00	1602	756	1938.0	0.0
57	4370.00	1825	1782	6734.0	2281.50
58	4612.00	2192	3232	918.0	2967.02
59	4602.00	1822	914	772.0	3609.53
60	3723.00	2099	604	875.0	0.0
61	3308.00	1370	996	1492.0	0.0
62	3976.00	2127	6749	2664.0	0.0
63	5075.00	2285	1084	31283.0	4708.55
64	4401.00	2320	555	580.0	2478.40
65	5239.00	2474	2024	8377.0	0.0
66	4828.00	2788	736	1132.0	1589.39
67	4009.00	2531	779	792.0	821.99
68	4990.00	2199	1522	1467.0	568.52
69	4662.00	2476	900	1033.0	2882.90
70	4342.00	3103	1251	1043.0	0.0
71	6053.00	2359	1969	6389.0	4371.21
72	6089.00	2233	1728	1251.0	3471.29
73	4604.00	2151	1301	1020.0	1875.86
74	5158.13	2270	1348	1159.0	1398.63
75	4743.91	2524	1477	776.0	789.83
76	5267.30	2277	1885	925.0	2056.31
77	4347.78	1908	902	623.0	1870.74
78	4090.43	1891	1012	660.0	2862.38
79	192.72	2570	1989	560.0	0.0
80	4478.85	1914	2174	1094.4	0.0
81	5061.64	2234	901	1615.0	1754.84
82	4888.13	2089	2740	1190.0	1535.00
83	5316.14	1799	1301	1298.0	2967.59
84	7509.15	6317	1195	2525.0	3373.70
85	5716.75	2796	1057	1057.0	2340.61

* "FEB1" indicates historical Feburary flows of the Big Wood River
* "FEB2" indicates historical Feburary flows of the Big Lost River
* "FEB3" indicates historical Feburary flows of the Goose Creek
* "FEB4" indicates historical Feburary flows of the Camas Creek
* "FEB4G" indicates generated Feburary flows of the Camas Creek

TABLE N.6

HISTORICAL MONTHLY FLOWS OF THE KEY STATION AND THREE SUBORDINATE STATIONS
VS.
GENERATED MONTHLY FLOWS OF THE KEY STATION

WYEAR	MAR1	MAR2	MAR3	MAR4	MAR4G
53	6541.00	2488	1340	11714	5514.84
54	5256.00	2227	1286	5191	0.0
55	3700.00	1652	1050	717	0.0
56	5853.00	2212	3368	5700	9259.48
57	5393.00	2220	1791	27548	4835.57
58	5093.00	2451	1777	2899	4821.19
59	5091.00	2015	1134	2905	5418.40
60	5730.00	2534	1778	1370	5137.22
61	3817.00	1459	1261	5548	5980.50
62	4298.00	2378	3785	1447	6593.01
63	5203.00	1987	1098	2423	770.80
64	4503.00	2170	1364	866	2458.59
65	6577.00	2608	1387	18172	4459.51
66	5544.00	2893	1736	8066	1622.40
67	5389.00	2401	1051	3352	4257.84
68	7165.00	2709	1507	7907	6744.79
69	5383.00	3078	2104	1486	4343.41
70	5689.00	2820	1120	7639	2330.34
71	6541.00	2453	2434	16194	8110.48
72	10385.00	3240	4145	43370	22054.51
73	4978.00	2497	2116	2497	4802.06
74	8997.40	3043	2941	29946	14940.91
75	5454.02	1965	3096	1668	6074.48
76	5770.25	2601	2972	1415	5484.77
77	4897.15	1801	1292	959	6564.74
78	6346.44	2532	1967	8629	9944.97
79	5164.08	3079	3976	8141	4960.69
80	5169.93	1885	1389	5077	1688.08
81	7023.70	2588	1242	5804	7738.08
82	7041.85	2527	2278	7823	9222.31
83	8114.26	1882	2329	23302	13261.21
84	8969.02	6003	2927	5516	7655.39
85	7316.81	3802	2419	1572	7821.68

* "MAR1" indicates historical March flows of the Big Wood River
* "MAR2" indicates historical March flows of the Big Lost River
* "MAR3" indicates historical March flows of the Goose Creek
* "MAR4" indicates historical March flows of the Camas Creek
* "MAR4G" indicates generated March flows of the Camas Creek

TABLE N.7

HISTORICAL MONTHLY FLOWS OF THE KEY STATION AND THREE SUBORDINATE STATIONS
VS.
GENERATED MONTHLY FLOWS OF THE KEY STATION

WYEAR	APR1	APR2	APR3	APR4	APR4G
53	18389.00	5144	2505	28167.0	22003.01
54	17562.00	6143	1596	24905.0	11344.40
55	4949.00	1913	1190	6285.0	5666.94
56	28958.00	9323	3700	65176.0	35214.42
57	11061.00	2688	2283	22824.0	23378.74
58	12221.00	3444	3300	40878.0	46118.49
59	11844.00	3665	1759	15358.0	20996.85
60	16726.00	5321	2235	34326.0	24327.55
61	7879.00	2226	1433	6719.0	12514.51
62	21650.00	9322	3842	48477.0	33717.57
63	7311.00	2774	1285	4479.0	14313.76
64	12535.00	4213	2464	27849.0	16748.18
65	26267.00	6934	3881	56662.0	70028.94
66	15408.00	5538	2076	23562.0	13311.98
67	9040.00	2316	1190	14826.0	11442.45
68	11358.00	4499	1448	3667.0	7103.23
69	39887.00	13431	4878	83176.0	105638.84
70	8853.00	3018	1672	30808.0	8561.39
71	16184.00	3621	4801	82010.0	56103.61
72	13215.00	4673	4764	24666.0	98107.84
73	9945.00	3355	4151	22473.0	42843.65
74	33506.87	10536	5385	40739.0	85572.15
75	6854.19	2075	2092	23006.0	13634.93
76	15087.68	6635	4252	40671.0	38148.91
77	5379.55	3506	1327	569.4	5208.23
78	19098.34	4423	4055	42615.0	66954.66
79	8865.90	4298	2717	6212.0	10705.60
80	19730.70	6206	3263	21374.0	47527.19
81	17668.14	8771	1670	5242.0	12097.10
82	15415.81	5643	3402	62423.0	26764.45
83	14808.50	3369	3334	62200.0	24873.51
84	19743.43	7572	5533	65561.0	54298.92
85	22425.58	8365	4625	34725.0	40116.93

* "APR1" indicates historical April flows of the Big Wood River
* "APR2" indicates historical April flows of the Big Lost River
* "APR3" indicates historical April flows of the Goose Creek
* "APR4" indicates historical April flows of the Camas Creek
* "APR4G" indicates generated April flows of the Camas Creek

TABLE N.8

HISTORICAL MONTHLY FLOWS OF THE KEY STATION AND THREE SUBORDINATE STATIONS
VS.
GENERATED MONTHLY FLOWS OF THE KEY STATION

WYEAR	MAY1	MAY2	MAY3	MAY4	MAY4G
53	24522.00	13473	4004.0	9567.0	9720.66
54	40383.00	29708	857.5	7307.0	4843.79
55	22147.00	11582	1957.0	7043.0	9347.84
56	72050.00	43554	4050.0	18306.0	19948.81
57	50838.00	27145	6604.0	17283.0	26719.99
58	90720.00	52702	7110.0	26334.0	34973.35
59	16992.00	8637	1073.0	4262.0	0.0
60	20689.00	12631	1544.0	7528.0	0.0
61	16352.00	13227	686.0	881.0	0.0
62	29946.00	16533	2957.0	13963.0	2699.99
63	37640.00	27695	2507.0	7764.0	3053.50
64	30527.00	21972	4685.0	9858.0	8714.71
65	64960.00	30733	5673.0	25534.0	34234.51
66	25525.00	19617	811.9	5011.0	0.0
67	58421.00	37683	2348.0	14917.0	17227.84
68	16855.00	16989	1052.0	455.0	0.0
69	94200.00	58282	3122.0	23195.0	21036.97
70	34402.00	26308	6928.0	14652.0	11314.69
71	67210.00	30514	9386.0	32282.0	46321.92
72	39171.00	22365	7962.0	15668.0	13373.71
73	26786.00	23951	7003.0	5906.0	0.0
74	69091.55	34510	7080.0	15388.0	30424.58
75	34155.35	14775	9428.0	45552.0	19548.54
76	46322.41	34883	7283.0	10568.0	4308.32
77	7333.32	6185	1273.0	422.1	4882.95
78	41236.07	17535	5043.0	15053.0	22195.63
79	28121.71	26017	5044.0	3873.0	0.0
80	53929.87	30024	5718.0	14834.0	11899.74
81	37822.64	28302	1138.0	4224.0	0.0
82	74780.02	32178	6955.0	31912.0	55182.85
83	67566.52	32464	8184.0	48124.0	40039.11
84	54876.18	35292	19379.0	32049.0	10102.13
85	32410.60	20219	3641.0	8198.0	9424.45

* "MAY1" indicates historical May flows of the Big Wood River
* "MAY2" indicates historical May flows of the Big Lost River
* "MAY3" indicates historical May flows of the Goose Creek
* "MAY4" indicates historical May flows of the Camas Creek
* "MAY4G" indicates generated May flows of the Camas Creek

TABLE N.9

HISTORICAL MONTHLY FLOWS OF THE KEY STATION AND THREE SUBORDINATE STATIONS
VS.
GENERATED MONTHLY FLOWS OF THE KEY STATION

WYEAR	JUN1	JUN2	JUN3	JUN4	JUN4G
53	46396.00	40653	3208.0	6295.0	3583.68
54	27940.00	24352	334.0	1674.0	100.85
55	35779.00	31421	782.0	2204.0	3490.01
56	65070.00	53520	925.9	5624.0	4323.74
57	58190.00	54063	2310.0	6056.0	5905.62
58	59390.00	42400	1873.0	7644.0	6551.87
59	28884.00	26788	493.6	603.0	3516.87
60	23092.00	23089	350.8	1109.9	0.0
61	23012.00	24284	430.4	376.1	3137.17
62	44461.00	41116	1778.0	7328.0	3311.39
63	48980.00	44643	2294.0	6720.0	5834.56
64	44230.00	38285	3831.0	4873.0	7883.12
65	89140.00	70440	2290.0	13012.0	10770.80
66	17244.00	14787	254.0	1130.0	0.0
67	83930.00	69560	2249.0	10449.0	7666.03
68	29887.00	40272	444.9	2722.0	0.0
69	60842.00	45363	833.0	6306.0	3089.09
70	50240.00	52592	3506.0	6785.0	4577.04
71	78570.00	55406	3604.0	11911.0	12706.72
72	76590.00	47800	3579.0	7904.0	7065.29
73	22479.00	26850	1560.0	1012.0	1539.25
74	96055.35	63100	1929.0	5046.0	11870.99
75	67545.67	56150	9949.0	8573.0	12501.55
76	33758.23	30735	1505.0	1809.0	1423.13
77	18006.78	23789	774.4	170.2	1297.91
78	54000.18	42080	1524.0	5660.0	5248.19
79	20469.58	20457	1447.0	368.2	592.60
80	50420.17	34944	3927.0	6560.0	5143.62
81	41263.99	40014	278.6	2101.0	0.0
82	87248.77	51855	2344.0	10919.0	14343.63
83	98468.14	66340	4848.0	18642.0	14560.05
84	60210.94	47554	9457.0	12798.0	7116.43
85	23522.14	18179	967.0	1603.0	1602.16

* "JUN1" indicates historical June flows of the Big Wood River
* "JUN2" indicates historical June flows of the Big Lost River
* "JUN3" indicates historical June flows of the Goose Creek
* "JUN4" indicates historical June flows of the Camas Creek
* "JUN4G" indicates generated June flows of the Camas Creek

TABLE N.9

HISTORICAL MONTHLY FLOWS OF THE KEY STATION AND THREE SUBORDINATE STATIONS
VS.
GENERATED MONTHLY FLOWS OF THE KEY STATION

WYEAR	JUN1	JUN2	JUN3	JUN4	JUN4G
53	46396.00	40653	3208.0	6295.0	3583.68
54	27940.00	24352	334.0	1674.0	100.85
55	35779.00	31421	782.0	2204.0	3490.01
56	65070.00	53520	925.9	5624.0	4323.74
57	58190.00	54063	2310.0	6056.0	5905.62
58	59390.00	42400	1873.0	7644.0	6551.87
59	28884.00	26788	493.6	603.0	3516.87
60	23092.00	23089	350.8	1109.9	0.0
61	23012.00	24284	430.4	376.1	3137.17
62	44461.00	41116	1778.0	7328.0	3311.39
63	48980.00	44643	2294.0	6720.0	5834.56
64	44230.00	38285	3831.0	4873.0	7883.12
65	89140.00	70440	2290.0	13012.0	10770.80
66	17244.00	14787	254.0	1130.0	0.0
67	83930.00	69560	2249.0	10449.0	7666.03
68	29887.00	40272	444.9	2722.0	0.0
69	60842.00	45363	833.0	6306.0	3089.09
70	50240.00	52592	3506.0	6785.0	4577.04
71	78570.00	55406	3604.0	11911.0	12706.72
72	76590.00	47800	3579.0	7904.0	7065.29
73	22479.00	26850	1560.0	1012.0	1539.25
74	96055.35	63100	1929.0	5046.0	11870.99
75	67545.67	56150	9949.0	8573.0	12501.55
76	33758.23	30735	1505.0	1809.0	1423.13
77	18006.78	23789	774.4	170.2	1297.91
78	54000.18	42080	1524.0	5660.0	5248.19
79	20469.58	20457	1447.0	368.2	592.60
80	50420.17	34944	3927.0	6560.0	5143.62
81	41263.99	40014	278.6	2101.0	0.0
82	87248.77	51855	2344.0	10919.0	14343.63
83	98468.14	66340	4848.0	18642.0	14560.05
84	60210.94	47554	9457.0	12798.0	7116.43
85	23522.14	18179	967.0	1603.0	1602.16

* "JUN1" indicates historical June flows of the Big Wood River
* "JUN2" indicates historical June flows of the Big Lost River
* "JUN3" indicates historical June flows of the Goose Creek
* "JUN4" indicates historical June flows of the Camas Creek
* "JUN4G" indicates generated June flows of the Camas Creek

TABLE N.11

HISTORICAL MONTHLY FLOWS OF THE KEY STATION AND THREE SUBORDINATE STATIONS
VS.
GENERATED MONTHLY FLOWS OF THE KEY STATION

WYEAR	AUG1	AUG2	AUG3	AUG4	AUG4G
53	9331.00	6325	651.60	207.1	209.175
54	7020.00	4776	83.00	133.9	115.961
55	6493.00	4857	286.40	104.6	46.503
56	9617.00	6467	163.20	148.9	216.457
57	8621.00	5868	254.40	151.8	127.779
58	10287.00	7338	390.20	159.9	265.547
59	4767.00	3552	133.90	96.2	106.827
60	3834.00	3033	135.70	85.2	60.015
61	4528.00	3059	359.30	59.0	96.044
62	8179.00	7196	373.10	167.4	119.545
63	8183.00	7087	202.50	107.6	164.990
64	8218.00	6002	355.50	146.7	72.082
65	21248.00	18170	594.00	1224.0	552.859
66	4507.00	3386	42.32	98.3	68.101
67	11305.00	9710	299.70	172.7	134.186
68	9212.00	9120	469.90	152.7	149.381
69	10043.00	7893	213.80	180.5	119.393
70	8866.00	6762	458.20	218.4	187.834
71	12812.00	9998	554.00	599.0	205.584
72	10238.00	6234	441.00	336.0	365.569
73	5639.00	5027	513.00	138.1	75.693
74	12391.63	7847	434.20	149.1	197.368
75	12600.81	10155	966.00	264.6	233.485
76	11120.94	8758	699.00	214.9	204.172
77	5399.71	4190	319.40	79.1	89.751
78	11082.96	7189	326.60	69.7	260.598
79	6486.50	5904	476.70	79.0	185.089
80	11652.93	7780	540.00	139.1	163.914
81	6876.95	5742	51.00	65.9	93.518
82	15986.58	12037	388.70	218.0	285.120
83	21177.28	16375	993.00	858.0	309.209
84	14948.61	14343	1641.00	639.0	518.628
85	7631.43	4514	552.00	157.9	217.989

* "AUG1" indicates historical August flows of the Big Wood River
* "AUG2" indicates historical August flows of the Big Lost River
* "AUG3" indicates historical August flows of the Goose Creek
* "AUG4" indicates historical August flows of the Camas Creek
* "AUG4G" indicates generated August flows of the Camas Creek

TABLE N.12

HISTORICAL MONTHLY FLOWS OF THE KEY STATION AND THREE SUBORDINATE STATIONS
VS.
GENERATED MONTHLY FLOWS OF THE KEY STATION

WYEAR	SEP1	SEP2	SEP3	SEP4	SEP4G
53	5599.00	3507	327.6	138.0	114.640
54	4873.00	2737	162.4	111.6	205.759
55	4318.00	2522	173.8	91.0	42.808
56	6744.00	3426	120.6	116.5	176.961
57	5993.00	3720	211.1	123.3	107.627
58	7328.00	4109	257.5	202.7	178.856
59	6880.00	4594	278.7	321.6	314.555
60	3671.00	2158	173.5	101.2	83.380
61	4745.00	3933	463.5	92.8	206.312
62	5800.00	3147	230.8	97.6	72.623
63	6597.00	5221	341.8	163.5	212.154
64	5514.00	3647	314.0	103.9	91.827
65	13367.00	7380	507.0	957.0	243.535
66	3901.00	2663	41.8	101.6	105.488
67	7968.00	5471	238.1	204.5	147.172
68	7332.00	6289	396.0	191.7	121.529
69	7671.00	4751	212.6	226.0	173.681
70	7543.00	4868	420.0	241.6	144.200
71	9977.00	5168	409.0	367.9	173.847
72	8010.00	4491	553.0	297.8	348.671
73	4886.00	4073	585.0	132.4	78.994
74	7906.38	4086	331.5	128.0	179.382
75	7933.37	5156	653.0	285.4	154.047
76	9539.45	8329	663.0	279.1	306.627
77	4837.99	2781	381.1	76.4	97.634
78	10564.87	9939	613.0	220.7	522.518
79	4757.55	3309	402.0	76.8	86.772
80	9567.12	6662	544.0	154.8	175.703
81	5052.00	3671	72.1	62.3	128.169
82	10110.40	6120	569.1	382.0	212.566
83	12672.75	6753	671.0	495.0	169.728
84	10125.68	8100	1186.0	468.0	208.911
85	11988.15	11326	657.0	322.6	520.007

* "SEP1" indicates historical September flows of the Big Wood River
* "SEP2" indicates historical September flows of the Big Lost River
* "SEP3" indicates historical September flows of the Goose Creek
* "SEP4" indicates historical September flows of the Camas Creek
* "SEP4G" indicates generated September flows of the Camas Creek

TABLE N.13

HISTORICAL ANNUAL FLOWS OF THE KEY STATION
VS.
GENERATED ANNUAL FLOWS OF THE KEY STATION

WYEAR	ANN4	ANN4G
53	62104.0	44942.37
54	42745.0	17808.93
55	18424.0	20853.99
56	103025.9	71132.11
57	84315.1	65584.88
58	81529.5	98859.24
59	26776.5	36931.14
60	47018.7	30825.21
61	16187.9	22433.01
62	76125.0	48206.04
63	55744.6	30648.64
64	46757.6	40581.12
65	150128.0	123697.36
66	44624.7	19727.56
67	48394.1	43471.43
68	19739.9	16486.08
69	119198.0	138674.85
70	65717.7	30622.68
71	158224.0	133642.83
72	99095.2	150599.60
73	37105.4	54514.91
74	96277.5	146687.71
75	85100.6	58212.69
76	59333.2	55665.89
77	4818.4	21971.63
78	76065.0	110773.57
79	20792.4	18099.56
80	51813.9	69191.31
81	21607.8	24431.94
82	119499.5	110371.39
83	163816.0	100447.51
84	129334.0	97735.94
85	52561.7	65343.12

* "ANN4" indicates historical Annual flows of the Camas Creek
* "ANN4G" indicates generated Annual flows of the Camas Creek

Fig. N.1

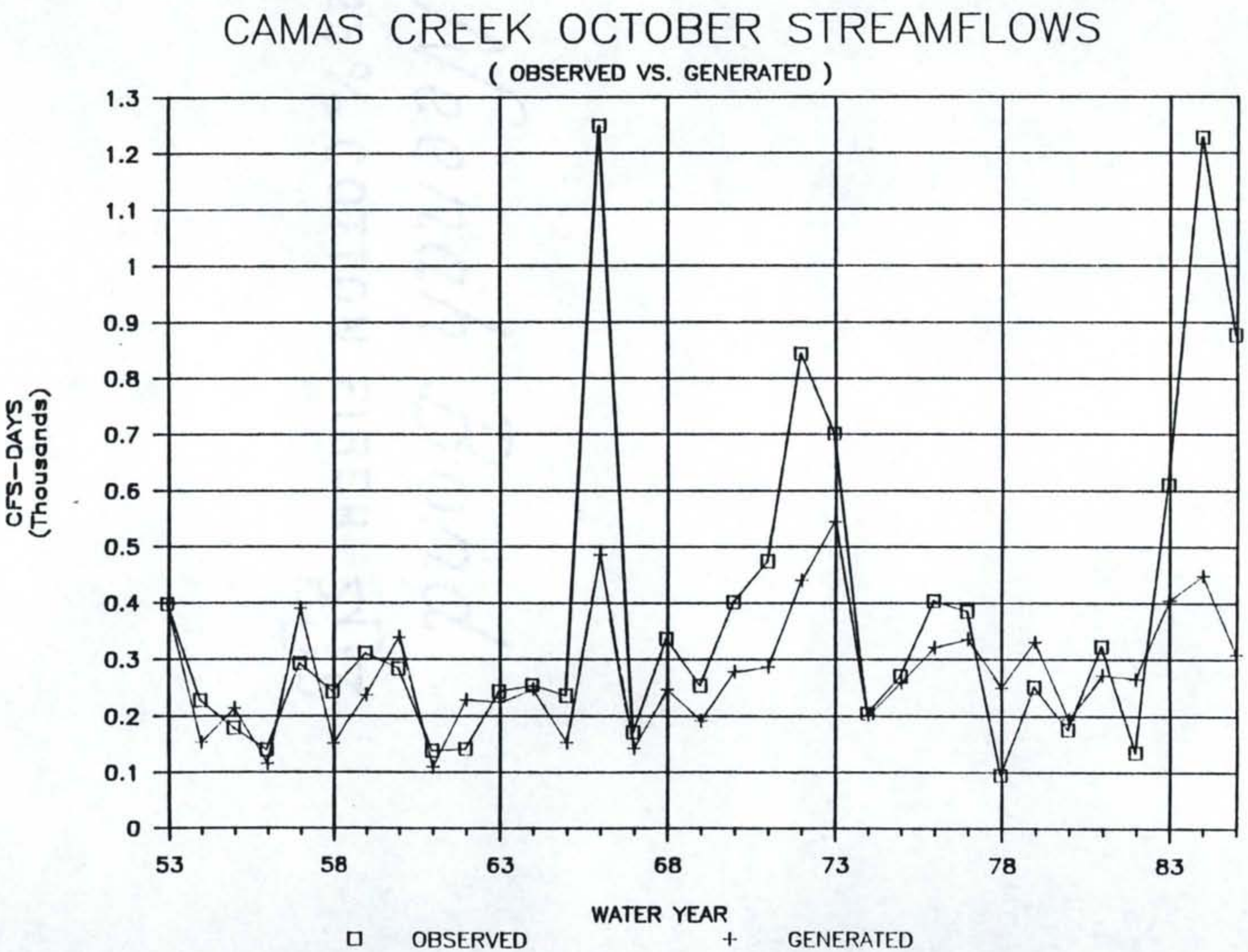

CAMAS CREEK OCTOBER STREAMFLOWS
(OBSERVED VS. GENERATED)
CFS-DAYS
(Thousands)
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
53
58
63
68
73
78
83
WATER YEAR
OBSERVED
GENERATED

Fig. N.2

CAMAS CREEK NOVEMBER STREAMFLOWS

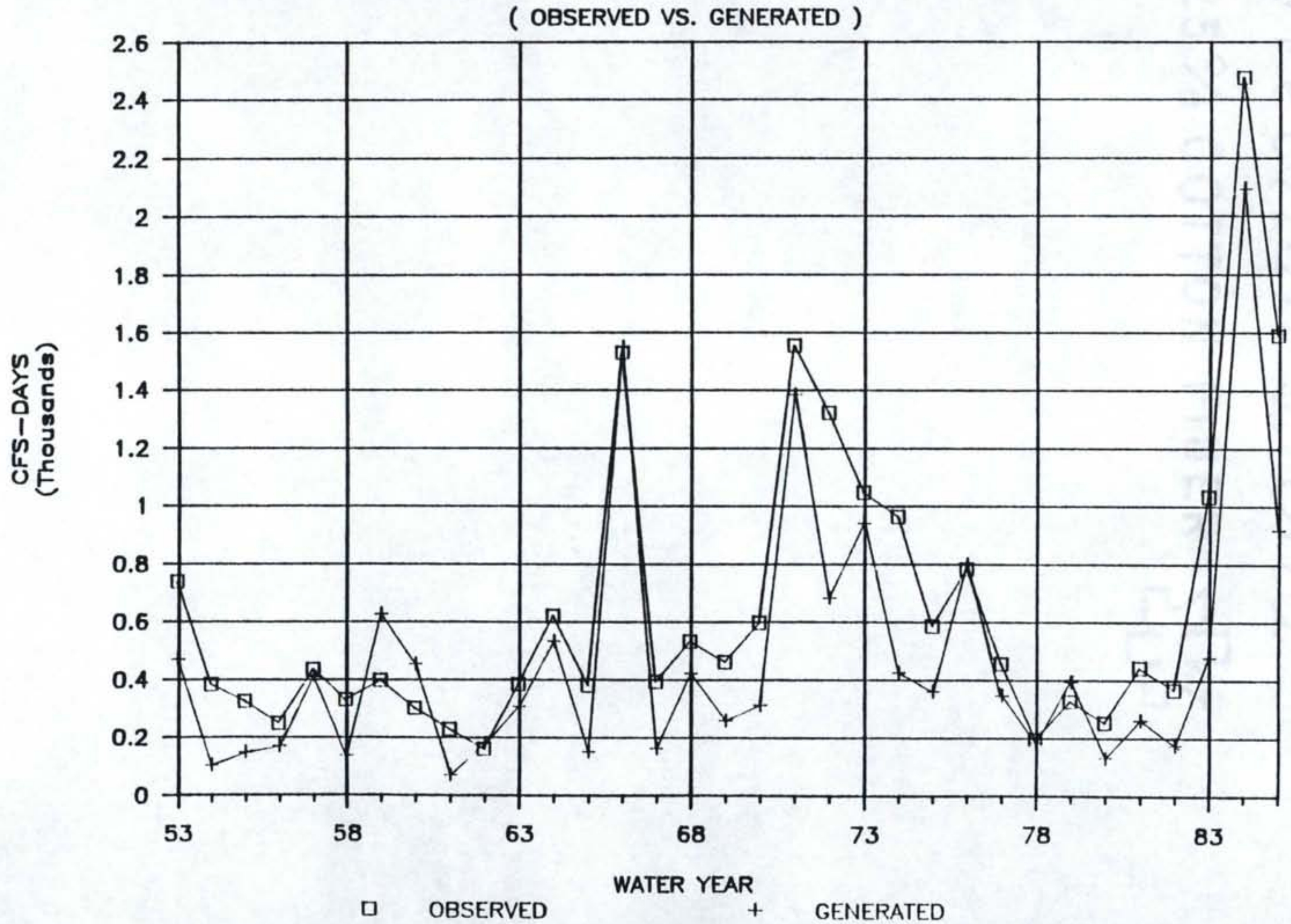


Fig. N.3

CAMAS CREEK DECEMBER STREAMFLOWS

(OBSERVED VS. GENERATED)

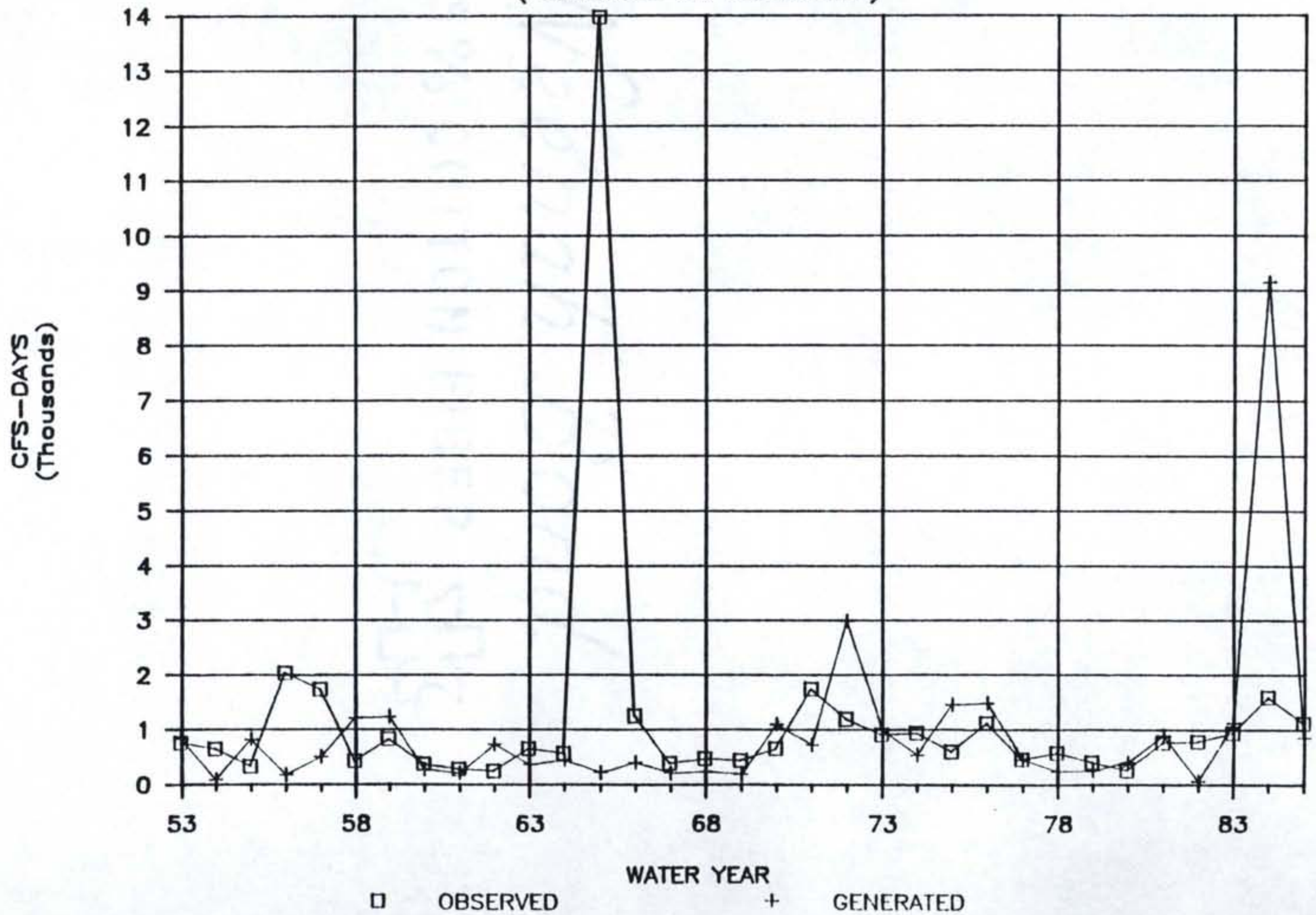


Fig. N.4

CAMAS CREEK JANUARY STREAMFLOWS

(OBSERVED VS. GENERATED)

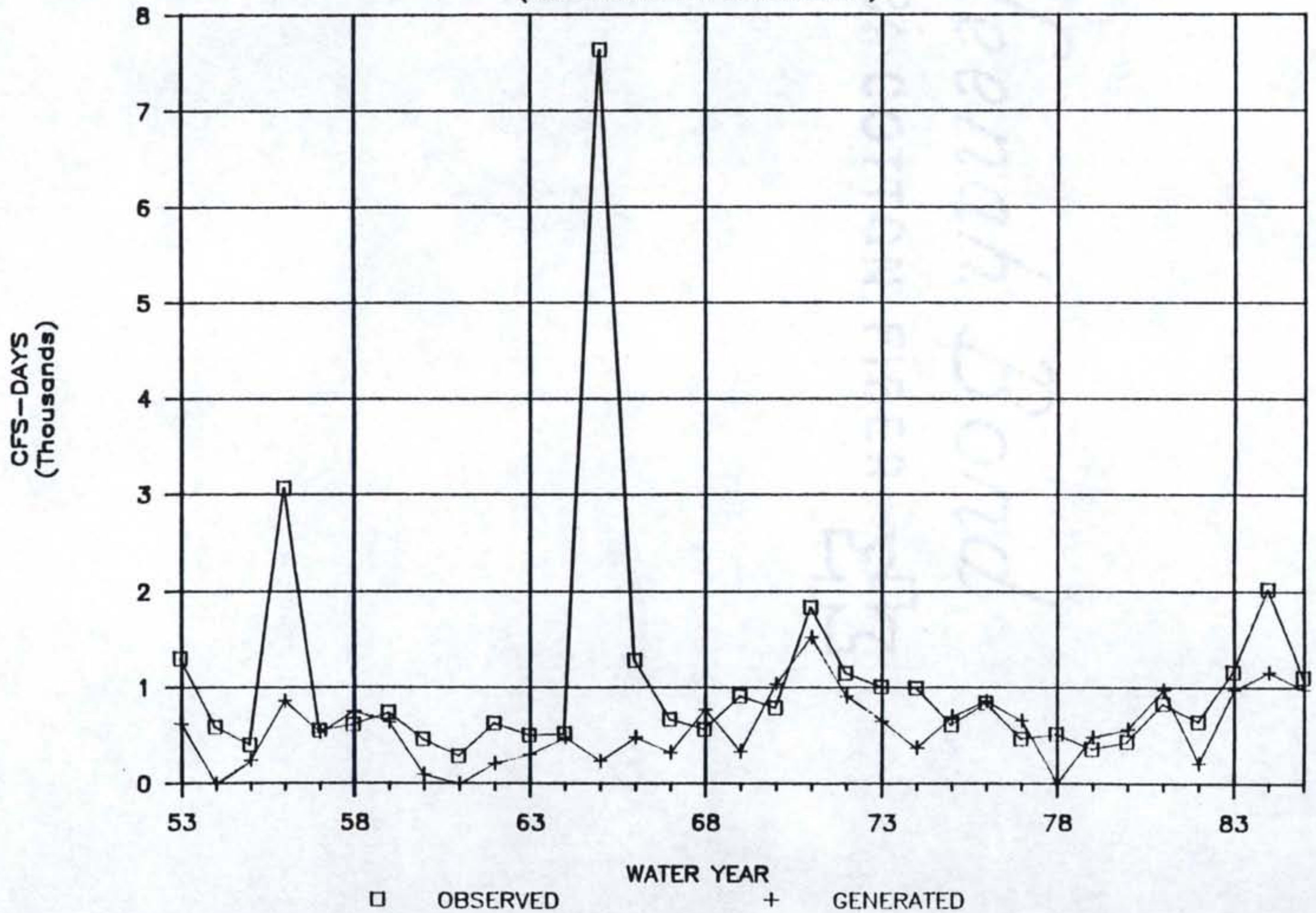
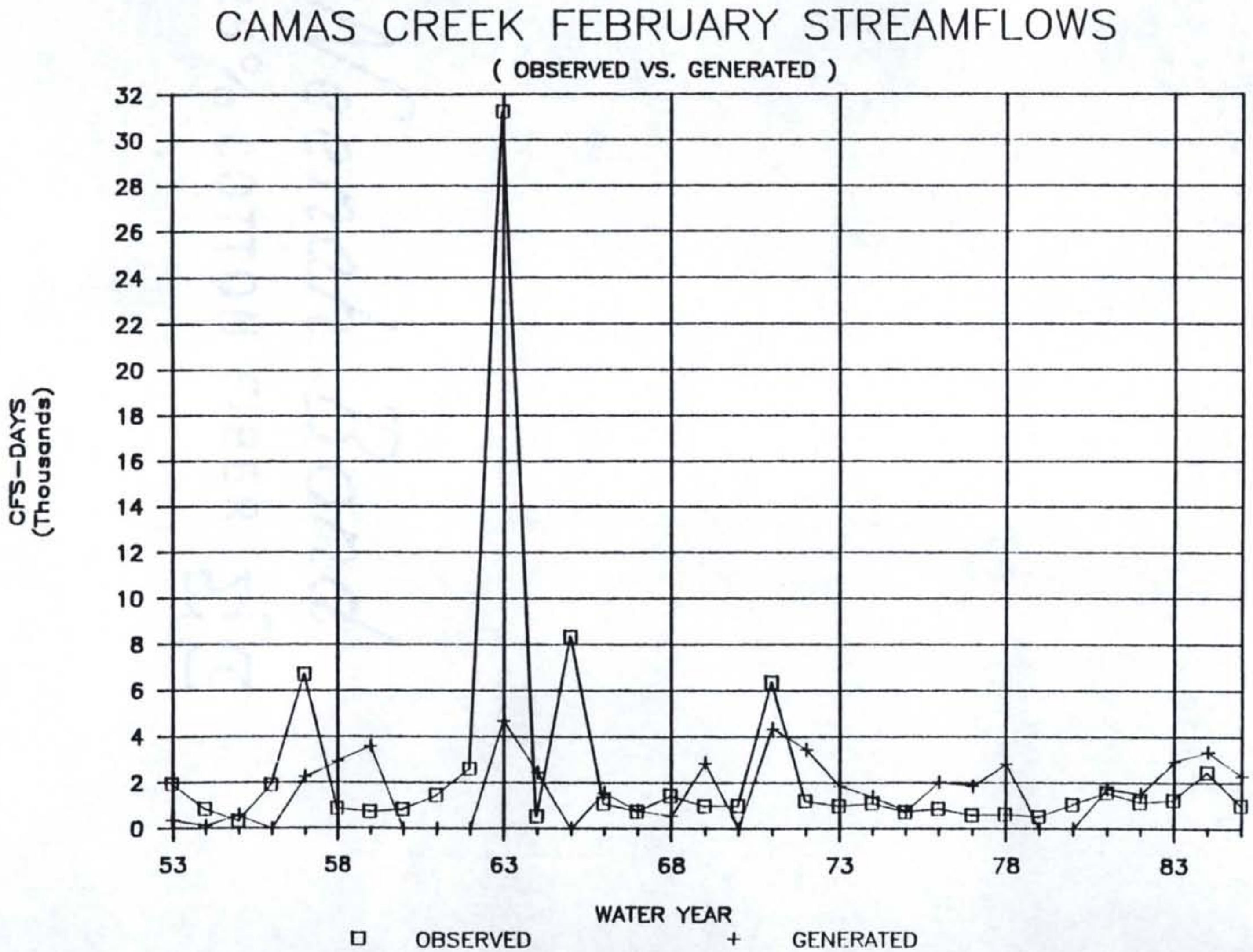


Fig. N.5



CAMAS CREEK FEBRUARY STREAMFLOWS
(OBSERVED VS. GENERATED)
CFS-DAYS
(Thousands)
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
53
58
63
68
73
78
83
WATER YEAR
OBSERVED
GENERATED

Fig. N.6

CAMAS CREEK MARCH STREAMFLOWS

(OBSERVED VS. GENERATED)

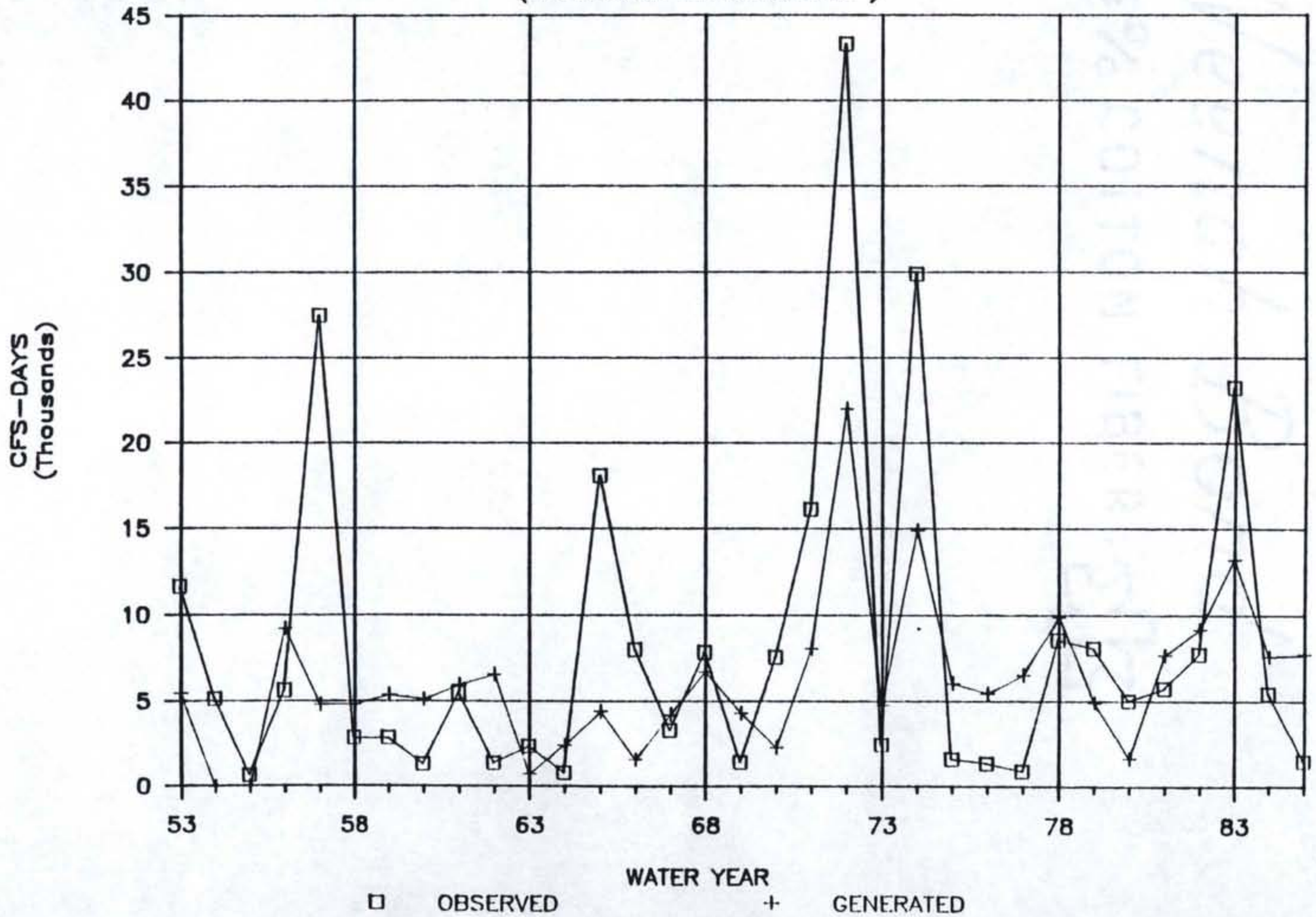


Fig. N.7

CAMAS CREEK APRIL STREAMFLOWS

(OBSERVED VS. GENERATED)

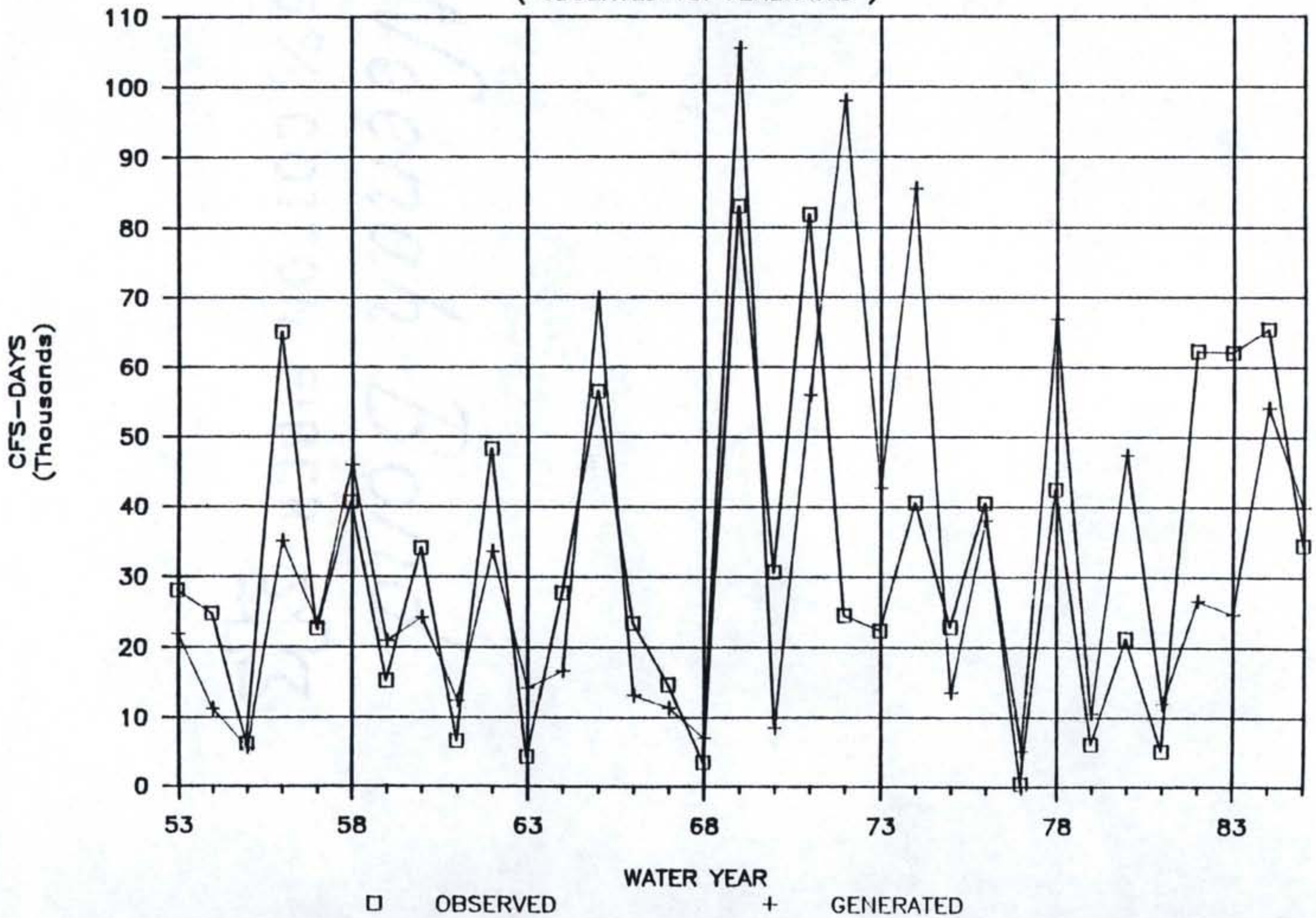
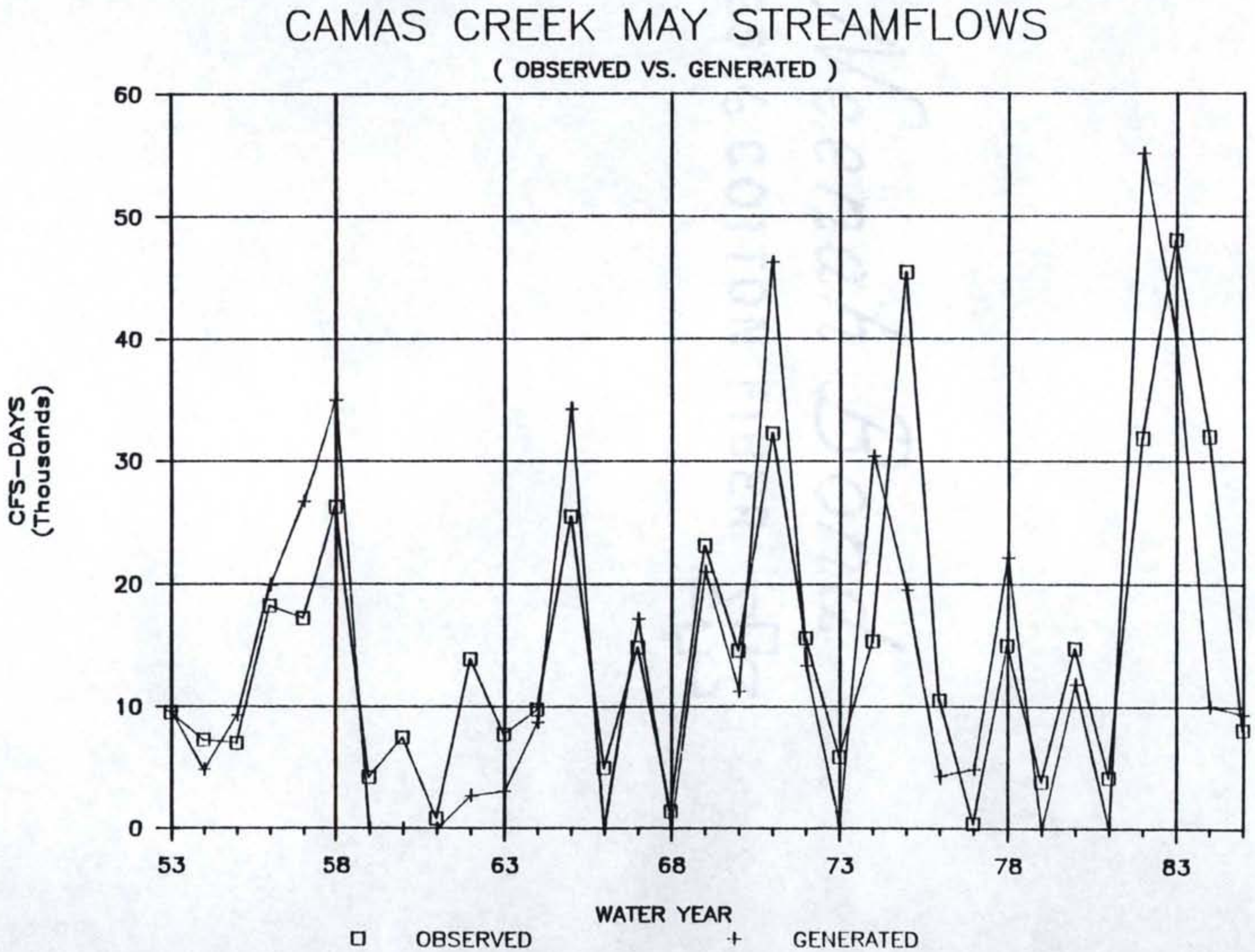


Fig. N.8



CAMAS CREEK MAY STREAMFLOWS
(OBSERVED VS. GENERATED)
CFS-DAYS
(Thousands)
60
50
40
30
20
10
0
53
58
63
68
73
78
83
WATER YEAR
OBSERVED
GENERATED

Fig. N.9

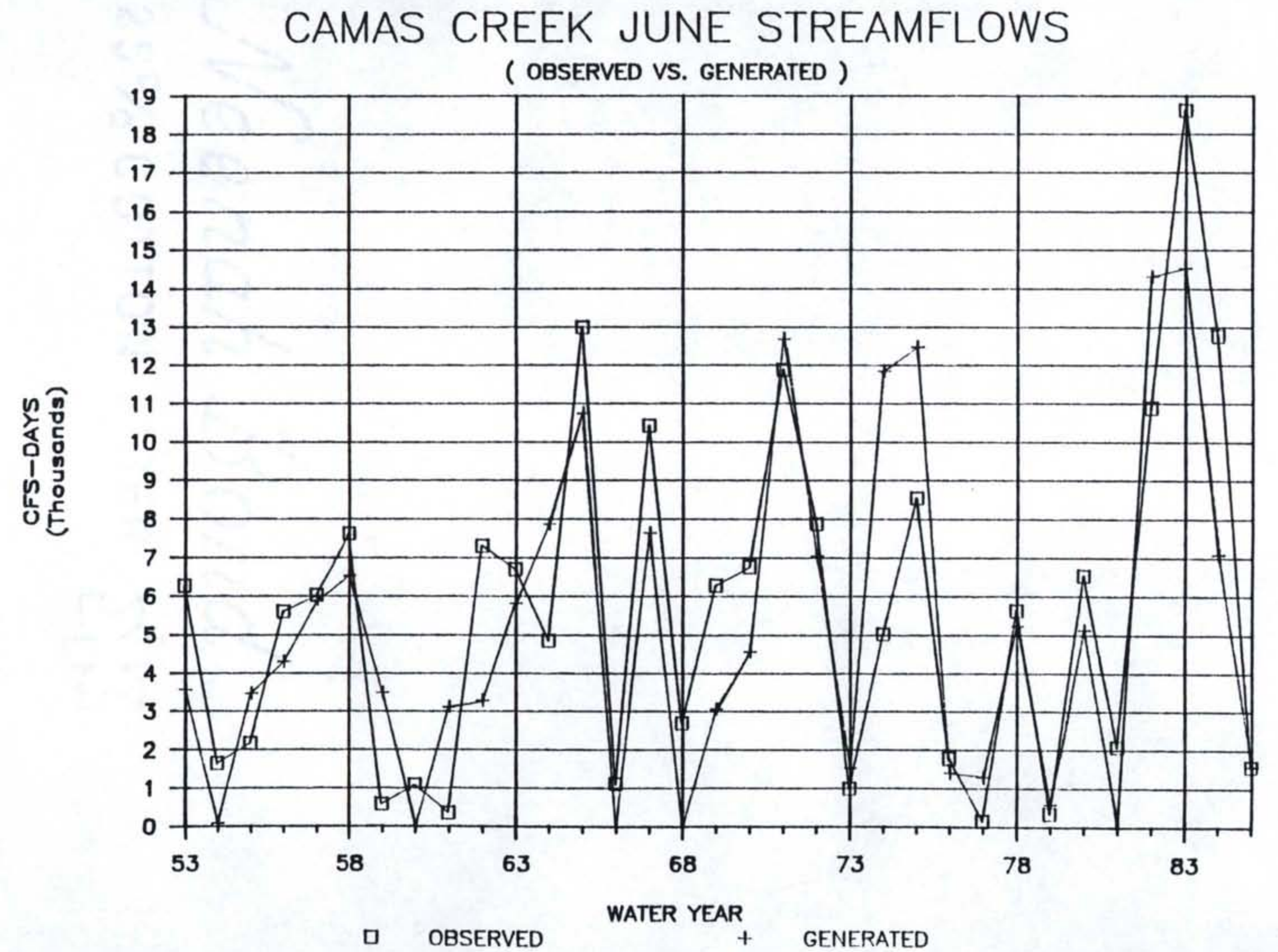

CAMAS CREEK JUNE STREAMFLOWS
(OBSERVED VS. GENERATED)
CFS—DAYS
(Thousands)
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
53
58
63
68
73
78
83
WATER YEAR
OBSERVED
GENERATED

Fig. N.10

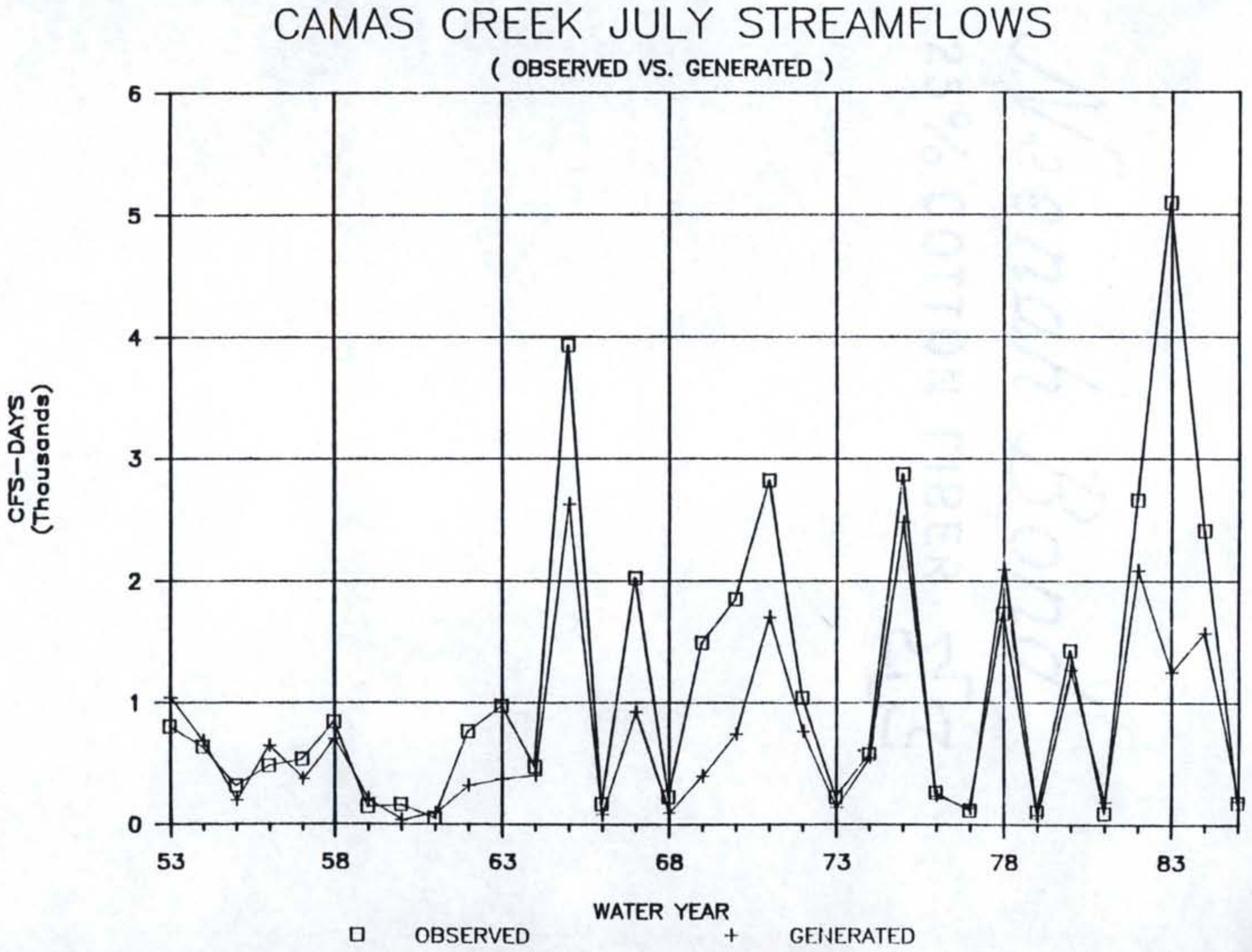

CAMAS CREEK JULY STREAMFLOWS
(OBSERVED VS. GENERATED)
CFS-DAYS
(Thousands)
0
1
2
3
4
5
6
53
58
63
68
73
78
83
WATER YEAR
OBSERVED
GENERATED

Fig. N.11

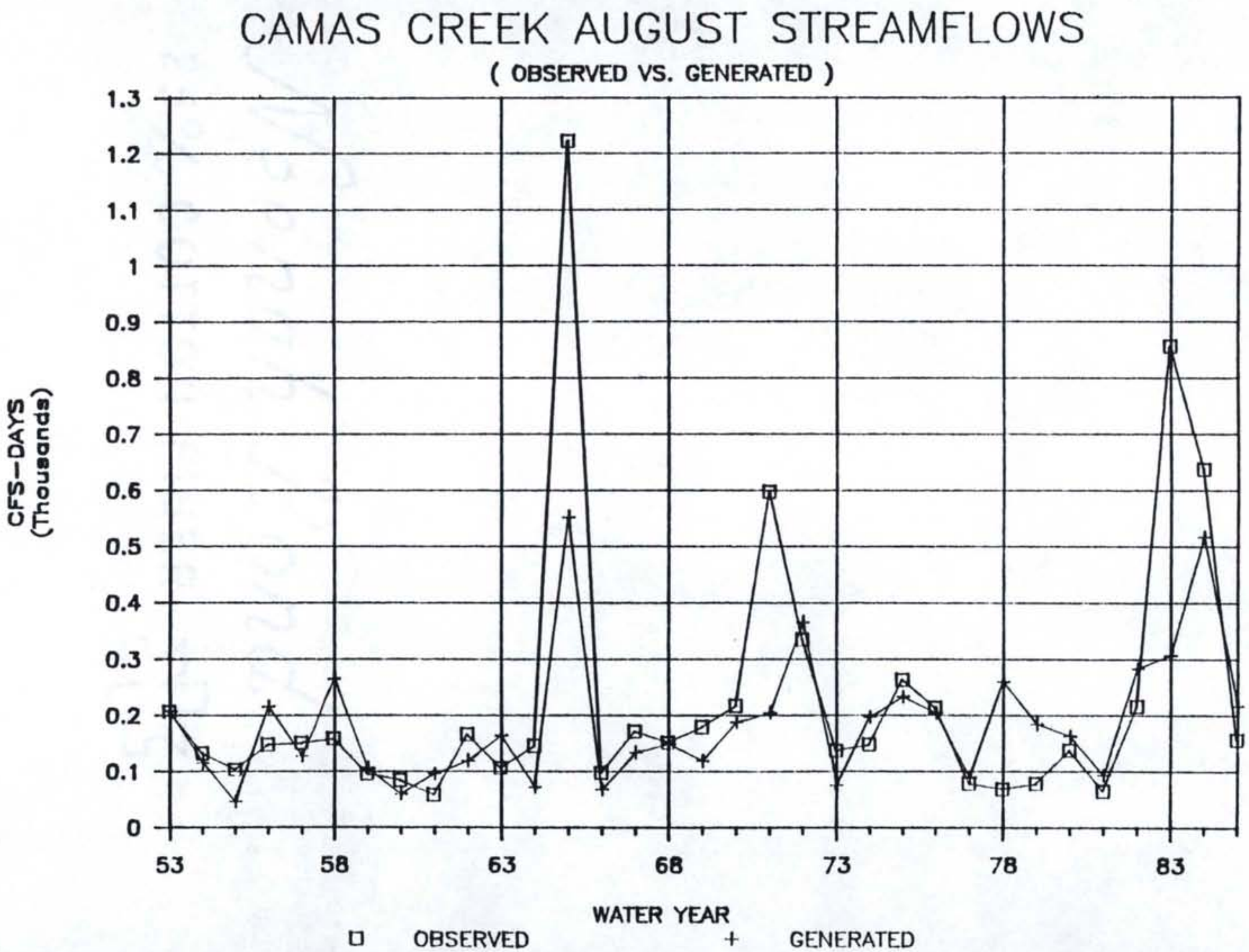

CAMAS CREEK AUGUST STREAMFLOWS
(OBSERVED VS. GENERATED)
CFS—DAYS (Thousands)
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
53
58
63
68
73
78
83
WATER YEAR
OBSERVED
GENERATED

Fig. N.12

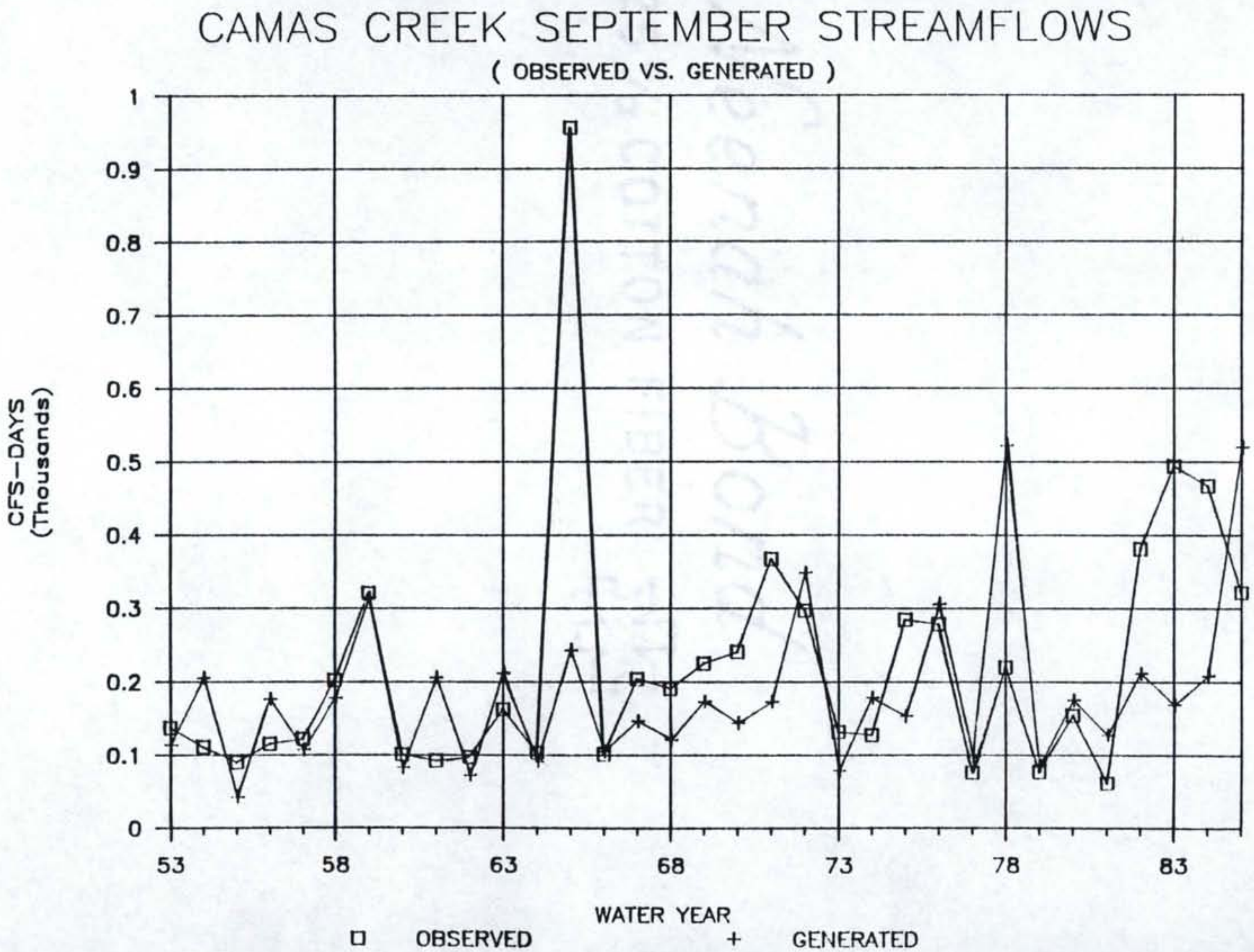
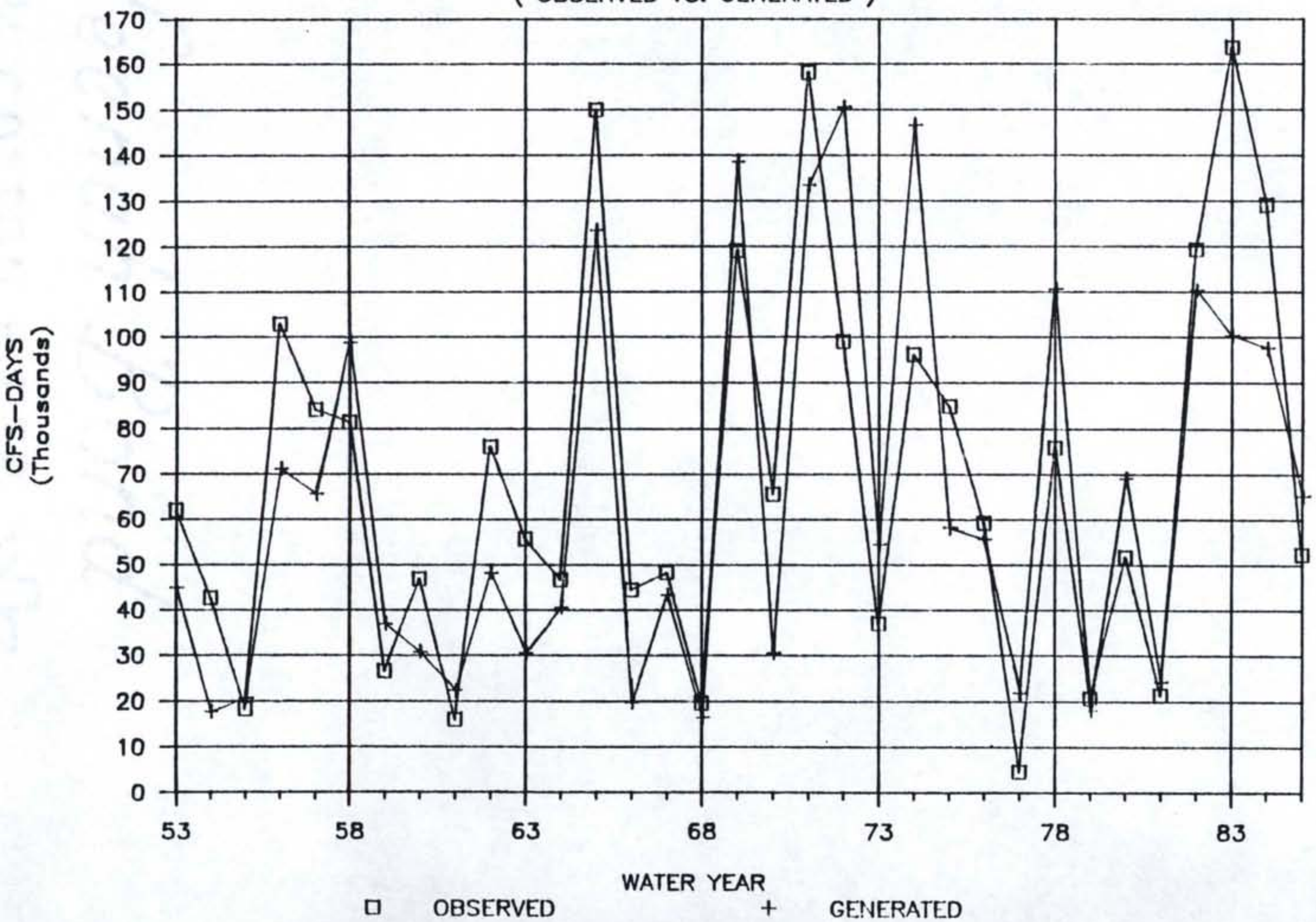

CAMAS CREEK SEPTEMBER STREAMFLOWS
(OBSERVED VS. GENERATED)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
CFS—DAYS
(Thousands)
53
58
63
68
73
78
83
WATER YEAR
OBSERVED
GENERATED

Fig. N.13

CAMAS CREEK ANNUAL STREAMFLOWS

(OBSERVED VS. GENERATED)



APPENDIX O

COEFFICIENTS OF SKEWNESS FOR HISTORICAL AND GENERATED MONTHLY FLOWS

Table O.1

Coefficients of Skewness for Historical and Generated Monthly Streamflows
Station: 13.1415.00
(Period: 1953 - 1985 Water Years)

Month	Skew Coeff (Historical)	Skew Coeff (Generated)
October	1.8792	0.5975
November	1.8326	2.0691
December	5.3962	4.6561
January	4.3220	0.3711
Feburary	4.8371	0.4207
March	2.0944	1.6253
April	0.6300	1.2411
May	1.2068	1.1394
June	0.8742	0.7638
July	1.5790	1.2473
August	2.7975	1.5889
September	2.5588	1.7518
Annual	0.6652	0.7108

APPENDIX P

DIFFERENCES BETWEEN HISTORICAL FLOWS AND GENERATED FLOWS

Table P.1

RATIOS BETWEEN HISTORICAL AND GENERATED FLOWS
(Streamflow in cfs-days)

WYEAR	OCT4	OCT4G	OCTRAT
53	400.0	400.000	1.00000
54	229.7	154.499	1.48674
55	181.0	215.726	0.83903
56	141.5	117.133	1.20803
57	294.8	392.107	0.75184
58	245.1	152.555	1.60663
59	312.7	238.744	1.30977
60	285.3	340.070	0.83894
61	139.9	110.920	1.26127
62	142.9	229.910	0.62155
63	245.5	225.753	1.08747
64	256.5	248.380	1.03269
65	238.0	154.354	1.54191
66	1251.0	487.384	2.56676
67	173.1	144.220	1.20025
68	338.0	248.290	1.36131
69	255.9	193.136	1.32497
70	403.7	280.073	1.44141
71	477.1	288.699	1.65259
72	846.0	442.136	1.91344
73	703.0	546.277	1.28689
74	207.0	203.099	1.01921
75	272.6	260.258	1.04742
76	406.4	322.562	1.25991
77	387.0	337.682	1.14605
78	96.5	251.547	0.38363
79	253.1	332.225	0.76183
80	178.2	195.795	0.91014
81	325.2	274.043	1.18668
82	137.3	266.261	0.51566
83	613.0	406.978	1.50622
84	1230.0	450.301	2.73151
85	880.0	310.482	2.83430

* "OCT4" indicates historical October flows
* "OCT4G" indicates generated October flows
* "OCTRAT" indicates OCT4/OCT4G
* " . " indicates division by zero

Table P.2

RATIOS BETWEEN HISTORICAL AND GENERATED FLOWS
(Streamflow in cfs-days)

WYEAR	NOV4	NOV4G	NOVRAT
53	744.0	473.20	1.57227
54	388.6	105.41	3.68656
55	330.4	150.42	2.19652
56	252.3	171.83	1.46831
57	441.0	413.44	1.06666
58	336.0	138.60	2.42424
59	402.5	630.24	0.63865
60	307.4	458.62	0.67027
61	232.5	73.20	3.17623
62	163.9	181.77	0.90169
63	389.3	310.60	1.25338
64	625.0	537.50	1.16279
65	385.0	154.08	2.49870
66	1535.0	1553.97	0.98779
67	398.1	164.90	2.41419
68	538.0	426.72	1.26078
69	467.9	262.50	1.78248
70	602.0	317.13	1.89828
71	1560.0	1389.58	1.12264
72	1328.0	685.97	1.93594
73	1052.0	945.08	1.11313
74	969.0	428.94	2.25906
75	590.0	363.76	1.62195
76	789.0	806.33	0.97851
77	461.0	351.13	1.31290
78	200.3	186.76	1.07250
79	331.8	398.98	0.83162
80	257.7	134.92	1.91002
81	447.0	264.48	1.69011
82	371.2	176.58	2.10216
83	1039.0	481.49	2.15788
84	2480.0	2096.43	1.18296
85	1595.0	921.94	1.73005

* "NOV4" indicates historical November flows
* "NOV4G" indicates generated November flows
* "NOVRAT" indicates NOV4/NOV4G
* " . " indicates division by zero

Table P.3

RATIOS BETWEEN HISTORICAL AND GENERATED FLOWS
(Streamflow in cfs-days)

WYEAR	DEC4	DEC4G	DECRAT
53	776.0	850.72	0.9122
54	665.0	102.32	6.4992
55	351.3	836.52	0.4200
56	2058.2	190.25	10.8184
57	1760.0	518.93	3.3916
58	445.0	1229.59	0.3619
59	848.0	1247.95	0.6795
60	394.0	279.35	1.4104
61	300.8	216.61	1.3887
62	269.2	746.05	0.3608
63	680.0	373.69	1.8197
64	589.0	456.46	1.2904
65	13990.0	232.21	60.2472
66	1273.0	419.32	3.0359
67	408.0	216.77	1.8822
68	499.0	251.48	1.9843
69	459.0	193.55	2.3715
70	674.0	1119.62	0.6020
71	1769.0	735.79	2.4042
72	1223.0	3002.66	0.4073
73	926.0	1014.91	0.9124
74	959.0	549.33	1.7458
75	620.0	1472.39	0.4211
76	1143.0	1503.70	0.7601
77	478.0	474.75	1.0068
78	596.9	248.08	2.4061
79	422.0	265.24	1.5910
80	273.0	418.84	0.6518
81	787.0	915.10	0.8600
82	811.0	79.61	10.1872
83	968.0	1145.57	0.8450
84	1618.0	9170.90	0.1764
85	1147.0	881.98	1.3005

* "DEC4" indicates historical December flows
* "DEC4G" indicates generated December flows
* "DECRAT" indicates DEC4/DEC4G
* " . " indicates division by zero

Table P.4

RATIOS BETWEEN HISTORICAL AND GENERATED FLOWS
(Streamflow in cfs-days)

WYEAR	JAN4	JAN4G	JANRAT
53	1313.0	626.64	2.0953
54	594.0	0.00	.
55	411.0	244.80	1.6789
56	3076.0	861.97	3.5686
57	558.0	530.05	1.0527
58	618.0	753.48	0.8202
59	747.0	640.22	1.1668
60	467.0	100.50	4.6468
61	290.3	0.00	.
62	634.0	209.48	3.0265
63	509.0	303.74	1.6758
64	527.0	485.04	1.0865
65	7640.0	239.62	31.8838
66	1288.0	485.12	2.6550
67	674.0	322.50	2.0899
68	569.0	774.89	0.7343
69	916.0	339.17	2.7007
70	794.0	1041.15	0.7626
71	1841.0	1528.91	1.2041
72	1160.0	912.97	1.2706
73	1017.0	652.08	1.5596
74	1003.0	374.50	2.6782
75	617.0	695.88	0.8866
76	845.0	864.63	0.9773
77	473.0	656.92	0.7200
78	521.0	0.00	.
79	363.6	490.99	0.7405
80	439.8	571.87	0.7691
81	834.0	978.84	0.8520
82	650.0	214.46	3.0309
83	1175.0	977.53	1.2020
84	2032.0	1167.77	1.7401
85	1114.0	984.49	1.1316

* "JAN4" indicates historical January flows
* "JAN4G" indicates generated January flows
* "JANRAT" indicates JAN4/JAN4G
* " . " indicates division by zero

Table P.5

RATIOS BETWEEN HISTORICAL AND GENERATED FLOWS
(Streamflow in cfs-days)

WYEAR	FEB4	FEB4G	FEBRAT
53	1971.0	399.68	4.93145
54	903.0	144.57	6.24611
55	383.0	612.81	0.62499
56	1938.0	0.00	.
57	6734.0	2281.50	2.95157
58	918.0	2967.02	0.30940
59	772.0	3609.53	0.21388
60	875.0	0.00	.
61	1492.0	0.00	.
62	2664.0	0.00	.
63	31283.0	4708.55	6.64387
64	580.0	2478.40	0.23402
65	8377.0	0.00	.
66	1132.0	1589.39	0.71222
67	792.0	821.99	0.96352
68	1467.0	568.52	2.58038
69	1033.0	2882.90	0.35832
70	1043.0	0.00	.
71	6389.0	4371.21	1.46161
72	1251.0	3471.29	0.36038
73	1020.0	1875.86	0.54375
74	1159.0	1398.63	0.82867
75	776.0	789.83	0.98249
76	925.0	2056.31	0.44983
77	623.0	1870.74	0.33302
78	660.0	2862.38	0.23058
79	560.0	0.00	.
80	1094.4	0.00	.
81	1615.0	1754.84	0.92031
82	1190.0	1535.00	0.77524
83	1298.0	2967.59	0.43739
84	2525.0	3373.70	0.74844
85	1057.0	2340.61	0.45159

* "FEB4" indicates historical February flows
* "FEB4G" indicates generated February flows
* "FEBRAT" indicates FEB4/FEB4G
* " . " indicates division by zero

Table P.6

RATIOS BETWEEN HISTORICAL ANDGENERATED FLOWS
(Streamflow in cfs-days)

WYEAR	MAR4	MAR4G	MARRAT
53	11714	5514.84	2.12409
54	5191	0.00	.
55	717	0.00	.
56	5700	9259.48	0.61559
57	27548	4835.57	5.69695
58	2899	4821.19	0.60130
59	2905	5418.40	0.53614
60	1370	5137.22	0.26668
61	5548	5980.50	0.92768
62	1447	6593.01	0.21947
63	2423	770.80	3.14349
64	866	2458.59	0.35223
65	18172	4459.51	4.07489
66	8066	1622.40	4.97165
67	3352	4257.84	0.78725
68	7907	6744.79	1.17231
69	1486	4343.41	0.34213
70	7639	2330.34	3.27806
71	16194	8110.48	1.99668
72	43370	22054.51	1.96649
73	2497	4802.06	0.51999
74	29946	14940.91	2.00430
75	1668	6074.48	0.27459
76	1415	5484.77	0.25799
77	959	6564.74	0.14608
78	8629	9944.97	0.86767
79	8141	4960.69	1.64110
80	5077	1688.08	3.00756
81	5804	7738.08	0.75006
82	7823	9222.31	0.84827
83	23302	13261.21	1.75715
84	5516	7655.39	0.72054
85	1572	7821.68	0.20098

* "MAR4" indicates historical March flows
* "MAR4G" indicates generated March flows
* "MARRAT" indicates MAR4/MAR4G
* " . " indicates division by zero

Table P.7

RATIOS BETWEEN HISTORICAL AND GENERATED FLOWS
(Streamflow in cfs-days)

WYEAR	APR4	APR4G	APRRAT
53	28167.0	22003.01	1.28014
54	24905.0	11344.40	2.19536
55	6285.0	5666.94	1.10906
56	65176.0	35214.42	1.85083
57	22824.0	23378.74	0.97627
58	40878.0	46118.49	0.88637
59	15358.0	20996.85	0.73144
60	34326.0	24327.55	1.41099
61	6719.0	12514.51	0.53690
62	48477.0	33717.57	1.43774
63	4479.0	14313.76	0.31292
64	27849.0	16748.18	1.66281
65	56662.0	70028.94	0.80912
66	23562.0	13311.98	1.76998
67	14826.0	11442.45	1.29570
68	3667.0	7103.23	0.51624
69	83176.0	105638.84	0.78736
70	30808.0	8561.39	3.59848
71	82010.0	56103.61	1.46176
72	24666.0	98107.84	0.25142
73	22473.0	42843.65	0.52454
74	40739.0	85572.15	0.47608
75	23006.0	13634.93	1.68728
76	40671.0	38148.91	1.06611
77	569.4	5208.23	0.10933
78	42615.0	66954.66	0.63648
79	6212.0	10705.60	0.58026
80	21374.0	47527.19	0.44972
81	5242.0	12097.10	0.43333
82	62423.0	26764.45	2.33231
83	62200.0	24873.51	2.50065
84	65561.0	54298.92	1.20741
85	34725.0	40116.93	0.86559

* "APR4" indicates historical April flows
* "APR4G" indicates generated April flows
* "APRRAT" indicates APR4/APR4G
* " . " indicates division by zero

Table P.8

RATIOS BETWEEN HISTORICAL AND GENERATED FLOWS
(Streamflow in cfs-days)

WYEAR	MAY4	MAY4G	MAYRAT
53	9567.0	9720.66	0.98419
54	7307.0	4843.79	1.50853
55	7043.0	9347.84	0.75344
56	18306.0	19948.81	0.91765
57	17283.0	26719.99	0.64682
58	26334.0	34973.35	0.75297
59	4262.0	0.00	.
60	7528.0	0.00	.
61	881.0	0.00	.
62	13963.0	2699.99	5.17150
63	7764.0	3053.50	2.54266
64	9858.0	8714.71	1.13119
65	25534.0	34234.51	0.74586
66	5011.0	0.00	.
67	14917.0	17227.84	0.86587
68	1455.0	0.00	.
69	23195.0	21036.97	1.10258
70	14652.0	11314.69	1.29495
71	32282.0	46321.92	0.69691
72	15668.0	13373.71	1.17155
73	5906.0	0.00	.
74	15388.0	30424.58	0.50578
75	45552.0	19548.54	2.33020
76	10568.0	4308.32	2.45293
77	422.1	4882.95	0.08644
78	15053.0	22195.63	0.67820
79	3873.0	0.00	.
80	14834.0	11899.74	1.24658
81	4224.0	0.00	.
82	31912.0	55182.85	0.57830
83	48124.0	40039.11	1.20192
84	32049.0	10102.13	3.17250
85	8198.0	9424.45	0.86987

* "MAY4" indicates historical May flows
* "MAY4G" indicates generated May flows
* "MAYRAT" indicates MAY4/MAY4G
* " . " indicates division by zero

Table P.9

RATIOS BETWEEN HISTORICAL AND GENERATED FLOWS
(Streamflow in cfs-days)

WYEAR	JUN4	JUN4G	JUNRAT
53	6295.0	3583.68	1.7566
54	1674.0	100.85	16.5989
55	2204.0	3490.01	0.6315
56	5624.0	4323.74	1.3007
57	6056.0	5905.62	1.0255
58	7644.0	6551.87	1.1667
59	603.0	3516.87	0.1715
60	1109.9	0.00	.
61	376.1	3137.17	0.1199
62	7328.0	3311.39	2.2130
63	6720.0	5834.56	1.1518
64	4873.0	7883.12	0.6182
65	13012.0	10770.80	1.2081
66	1130.0	0.00	.
67	10449.0	7666.03	1.3630
68	2722.0	0.00	.
69	6306.0	3089.09	2.0414
70	6785.0	4577.04	1.4824
71	11911.0	12706.72	0.9374
72	7904.0	7065.29	1.1187
73	1012.0	1539.25	0.6575
74	5046.0	11870.99	0.4251
75	8573.0	12501.55	0.6858
76	1809.0	1423.13	1.2711
77	170.2	1297.91	0.1311
78	5660.0	5248.19	1.0785
79	368.2	592.60	0.6213
80	6560.0	5143.62	1.2754
81	2101.0	0.00	.
82	10919.0	14343.63	0.7612
83	18642.0	14560.05	1.2804
84	12798.0	7116.43	1.7984
85	1603.0	1602.16	1.0005

* "JUN4" indicates historical June flows
* "JUN4G" indicates generated June flows
* "JUNRAT" indicates JUN4/JUN4G
* " . " indicates division by zero

Table P.10

RATIOS BETWEEN HISTORICAL AND GENERATED FLOWS
(Streamflow in cfs-days)

WYEAR	JUL4	JUL4G	JULRAT
53	811.9	1046.13	0.77610
54	642.2	691.37	0.92888
55	322.7	199.61	1.61665
56	488.5	651.06	0.75031
57	541.2	373.53	1.44888
58	849.8	708.69	1.19911
59	148.5	210.95	0.70396
60	169.7	38.51	4.40665
61	56.5	97.74	0.57806
62	771.0	324.70	2.37450
63	980.7	376.54	2.60450
64	483.5	406.83	1.18846
65	3937.0	2626.94	1.49870
66	176.8	84.41	2.09454
67	2027.7	925.53	2.19085
68	233.5	97.25	2.40103
69	1496.7	402.21	3.72119
70	1857.0	749.21	2.47861
71	2824.0	1706.48	1.65487
72	1045.4	768.98	1.35946
73	228.9	141.06	1.62271
74	584.4	547.83	1.06675
75	2876.0	2483.54	1.15802
76	267.8	236.43	1.13268
77	120.2	139.19	0.86357
78	1742.9	2098.24	0.83065
79	111.9	81.37	1.37520
80	1431.9	1271.64	1.12603
81	100.4	187.77	0.53470
82	2663.0	2088.55	1.27505
83	5102.0	1255.53	4.06362
84	2418.0	1576.43	1.53385
85	190.2	200.40	0.94910

* "JUL4" indicates historical July flows
* "JUL4G" indicates generated July flows
* "JULRAT" indicates JUL4/JUL4G
* " . " indicates division by zero

Table P.11

RATIOS BETWEEN HISTORICAL AND GENERATED FLOWS
(Streamflow in cfs-days)

WYEAR	AUG4	AUG4G	AUGRAT
53	207.1	209.175	0.99008
54	133.9	115.961	1.15470
55	104.6	46.503	2.24932
56	148.9	216.457	0.68790
57	151.8	127.779	1.18799
58	159.9	265.547	0.60215
59	96.2	106.827	0.90052
60	85.2	60.015	1.41965
61	59.0	96.044	0.61430
62	167.4	119.545	1.40031
63	107.6	164.990	0.65216
64	146.7	72.082	2.03518
65	1224.0	552.859	2.21395
66	98.3	68.101	1.44344
67	172.7	134.186	1.28702
68	152.7	149.381	1.02222
69	180.5	119.393	1.51181
70	218.4	187.834	1.16273
71	599.0	205.584	2.91365
72	336.0	365.569	0.91912
73	138.1	75.693	1.82448
74	149.1	197.368	0.75544
75	264.6	233.485	1.13326
76	214.9	204.172	1.05254
77	79.1	89.751	0.88133
78	69.7	260.598	0.26746
79	79.0	185.089	0.42682
80	139.1	163.914	0.84862
81	65.9	93.518	0.70468
82	218.0	285.120	0.76459
83	858.0	309.209	2.77482
84	639.0	518.628	1.23210
85	157.9	217.989	0.72435

* "AUG4" indicates historical August flows
* "AUG4G" indicates generated August flows
* "AUGRAT" indicates AUG4/AUG4G
* " . " indicates division by zero

Table P.12

RATIOS BETWEEN HISTORICAL AND GENERATED FLOWS
(Streamflow in cfs-days)

WYEAR	SEP4	SEP4G	SEPRAT
53	138.0	114.640	1.20377
54	111.6	205.759	0.54238
55	91.0	42.808	2.12577
56	116.5	176.961	0.65834
57	123.3	107.627	1.14562
58	202.7	178.856	1.13331
59	321.6	314.555	1.02240
60	101.2	83.380	1.21372
61	92.8	206.312	0.44980
62	97.6	72.623	1.34393
63	163.5	212.154	0.77067
64	103.9	91.827	1.13148
65	957.0	243.535	3.92962
66	101.6	105.488	0.96314
67	204.5	147.172	1.38953
68	191.7	121.529	1.57740
69	226.0	173.681	1.30124
70	241.6	144.200	1.67545
71	367.9	173.847	2.11623
72	297.8	348.671	0.85410
73	132.4	78.994	1.67608
74	128.0	179.382	0.71356
75	285.4	154.047	1.85268
76	279.1	306.627	0.91023
77	76.4	97.634	0.78251
78	220.7	522.518	0.42238
79	76.8	86.772	0.88508
80	154.8	175.703	0.88103
81	62.3	128.169	0.48608
82	382.0	212.566	1.79709
83	495.0	169.728	2.91643
84	468.0	208.911	2.24019
85	322.6	520.007	0.62038

* "SEP4" indicates historical September flows
* "SEP4G" indicates generated September flows
* "SEPRAT" indicates SEP4/SEP4G
* " . " indicates division by zero

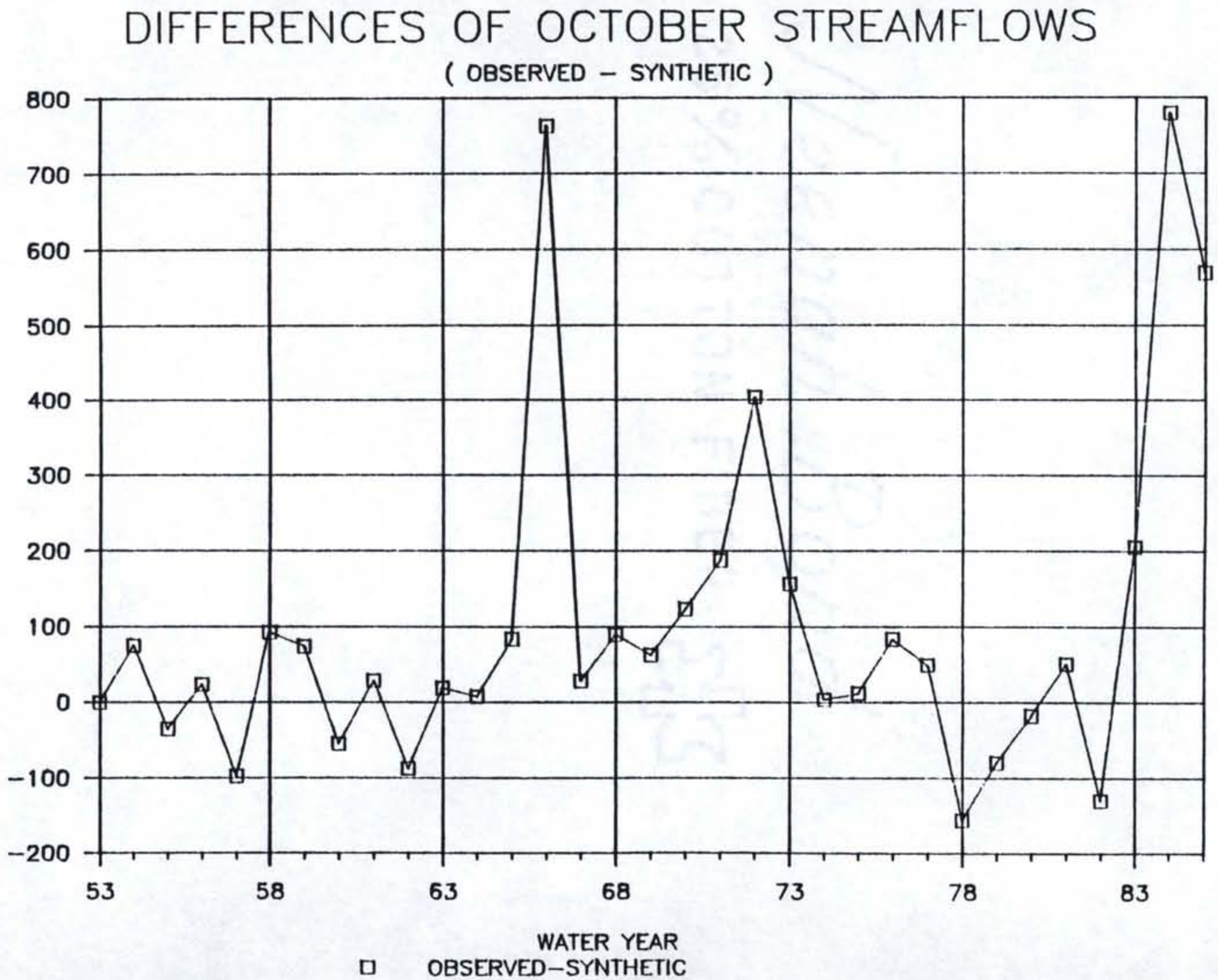
Table P.13

RATIOS BETWEEN HISTORICAL AND GENERATED FLOWS
(Streamflow in cfs-days)

WYEAR	ANN4	ANNG	ANNRAT
53	62104.0	44942.37	1.38186
54	42745.0	17808.93	2.40020
55	18424.0	20853.99	0.88348
56	103025.9	71132.11	1.44837
57	84315.1	65584.88	1.28559
58	81529.5	98859.24	0.82470
59	26776.5	36931.14	0.72504
60	47018.7	30825.21	1.52533
61	16187.9	22433.01	0.72161
62	76125.0	48206.04	1.57916
63	55744.6	30648.64	1.81883
64	46757.6	40581.12	1.15220
65	150128.0	123697.36	1.21367
66	44624.7	19727.56	2.26205
67	48394.1	43471.43	1.11324
68	19739.9	16486.08	1.19737
69	119198.0	138674.85	0.85955
70	65717.7	30622.68	2.14605
71	158224.0	133642.83	1.18393
72	99095.2	150599.60	0.65800
73	37105.4	54514.91	0.68065
74	96277.5	146687.71	0.65634
75	85100.6	58212.69	1.46189
76	59333.2	55665.89	1.06588
77	4818.4	21971.63	0.21930
78	76065.0	110773.57	0.68667
79	20792.4	18099.56	1.14878
80	51813.9	69191.31	0.74885
81	21607.8	24431.94	0.88441
82	119499.5	110371.39	1.08270
83	163816.0	100447.51	1.63086
84	129334.0	97735.94	1.32330
85	52561.7	65343.12	0.80440

* "ANN4" indicates historical Annual flows
* "ANN4G" indicates generated Annual flows
* "ANNRAT" indicates ANN4/ANN4G
* " . " indicates division by zero

Fig. P.1



DIFFERENCES OF OCTOBER STREAMFLOWS
(OBSERVED – SYNTHETIC)
CFS–DAYS
800
700
600
500
400
300
200
100
0
–100
–200
53
58
63
68
73
78
83
WATER YEAR
OBSERVED–SYNTHETIC

Fig. P.2

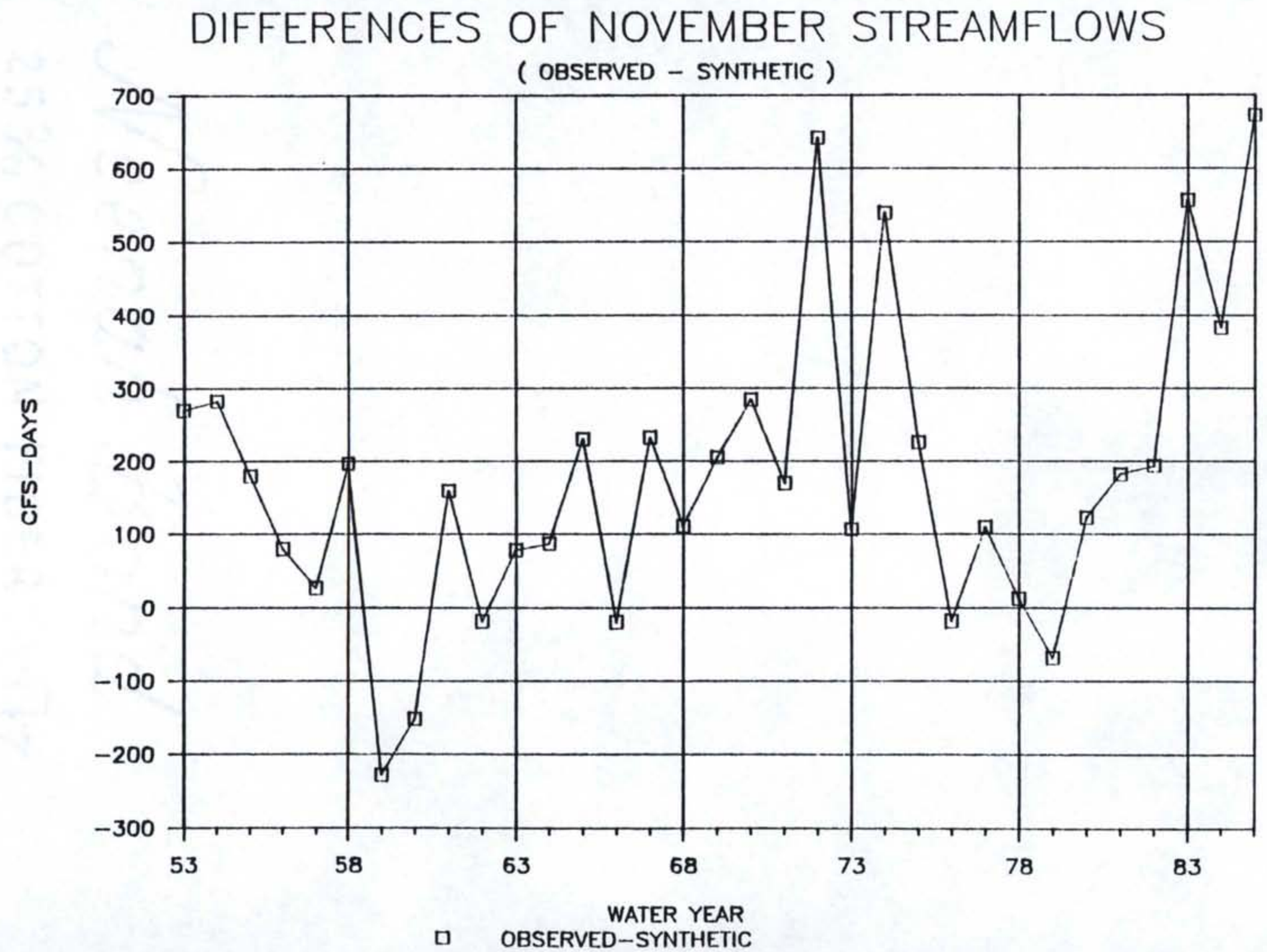

DIFFERENCES OF NOVEMBER STREAMFLOWS
(OBSERVED - SYNTHETIC)
CFS-DAYS
700
600
500
400
300
200
100
0
-100
-200
-300
53
58
63
68
73
78
83
WATER YEAR
OBSERVED-SYNTHETIC

Fig. P.3

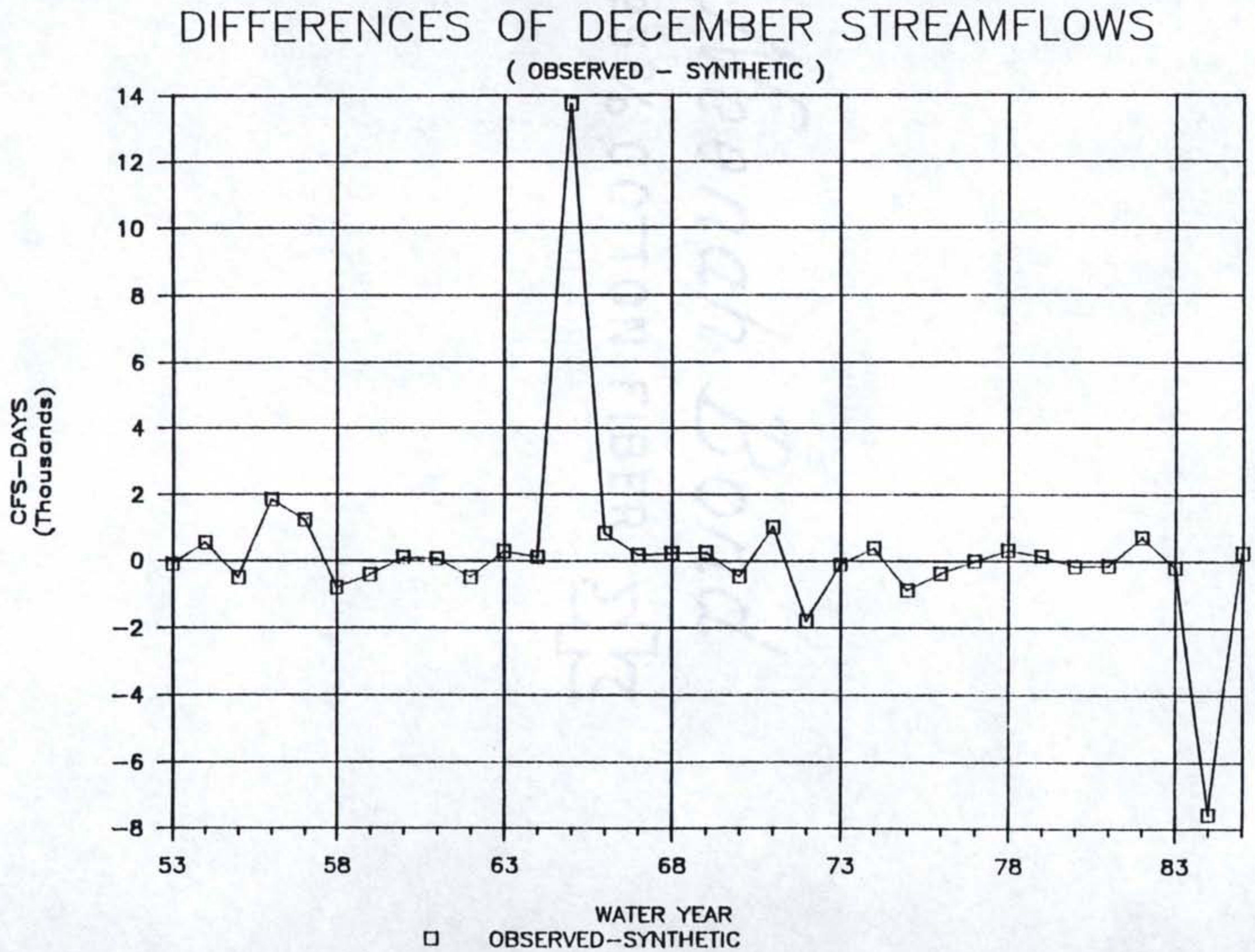
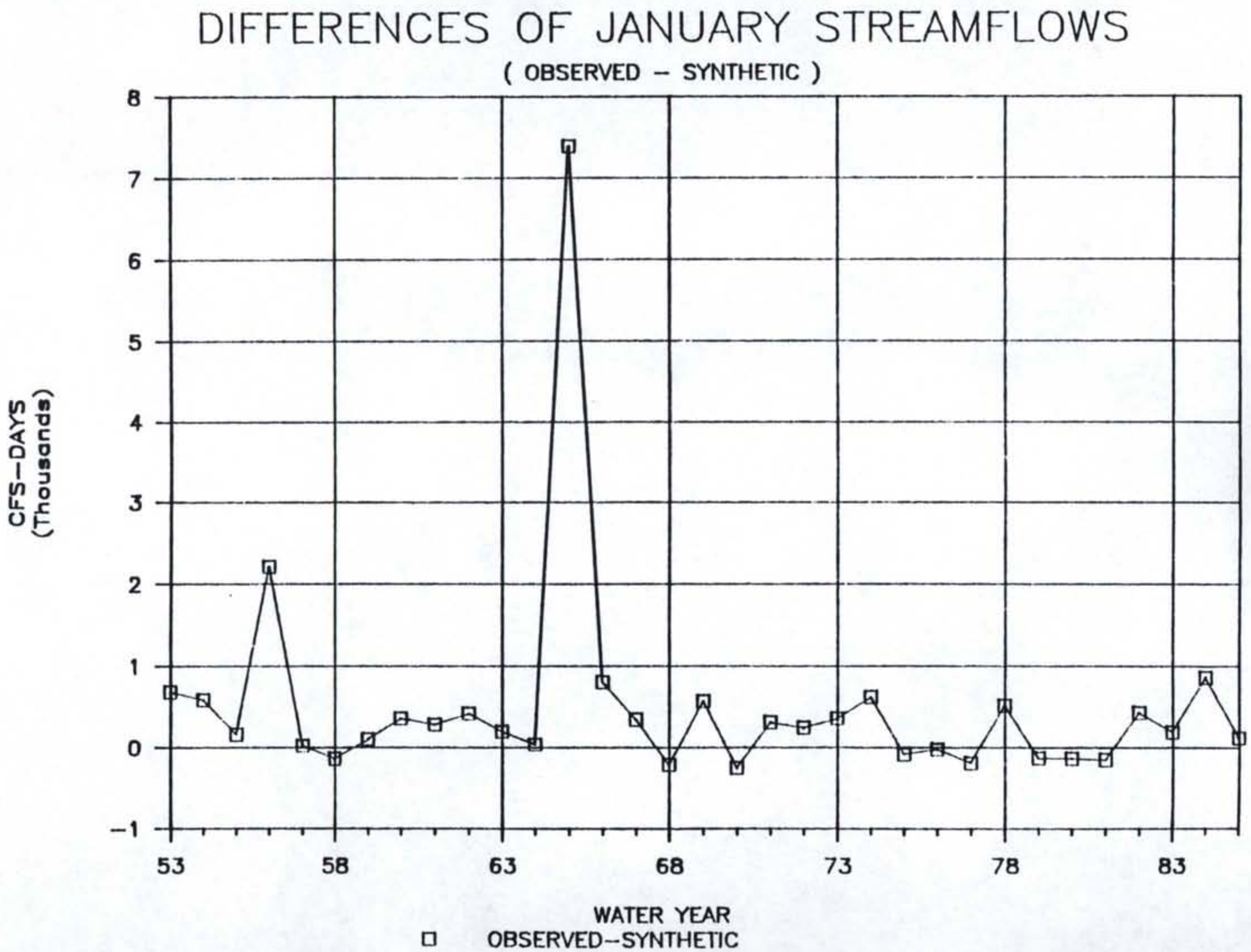

DIFFERENCES OF DECEMBER STREAMFLOWS
(OBSERVED - SYNTHETIC)
CFS-DAYS
(Thousands)
14
12
10
8
6
4
2
0
-2
-4
-6
-8
53
58
63
68
73
78
83
WATER YEAR
OBSERVED-SYNTHETIC

Fig. P.4



DIFFERENCES OF JANUARY STREAMFLOWS
(OBSERVED – SYNTHETIC)
CFS–DAYS
(Thousands)
8
7
6
5
4
3
2
1
0
–1
53
58
63
68
73
78
83
WATER YEAR
OBSERVED–SYNTHETIC

Fig. P.5

DIFFERENCES OF FEBRUARY STREAMFLOWS

(OBSERVED – SYNTHETIC)

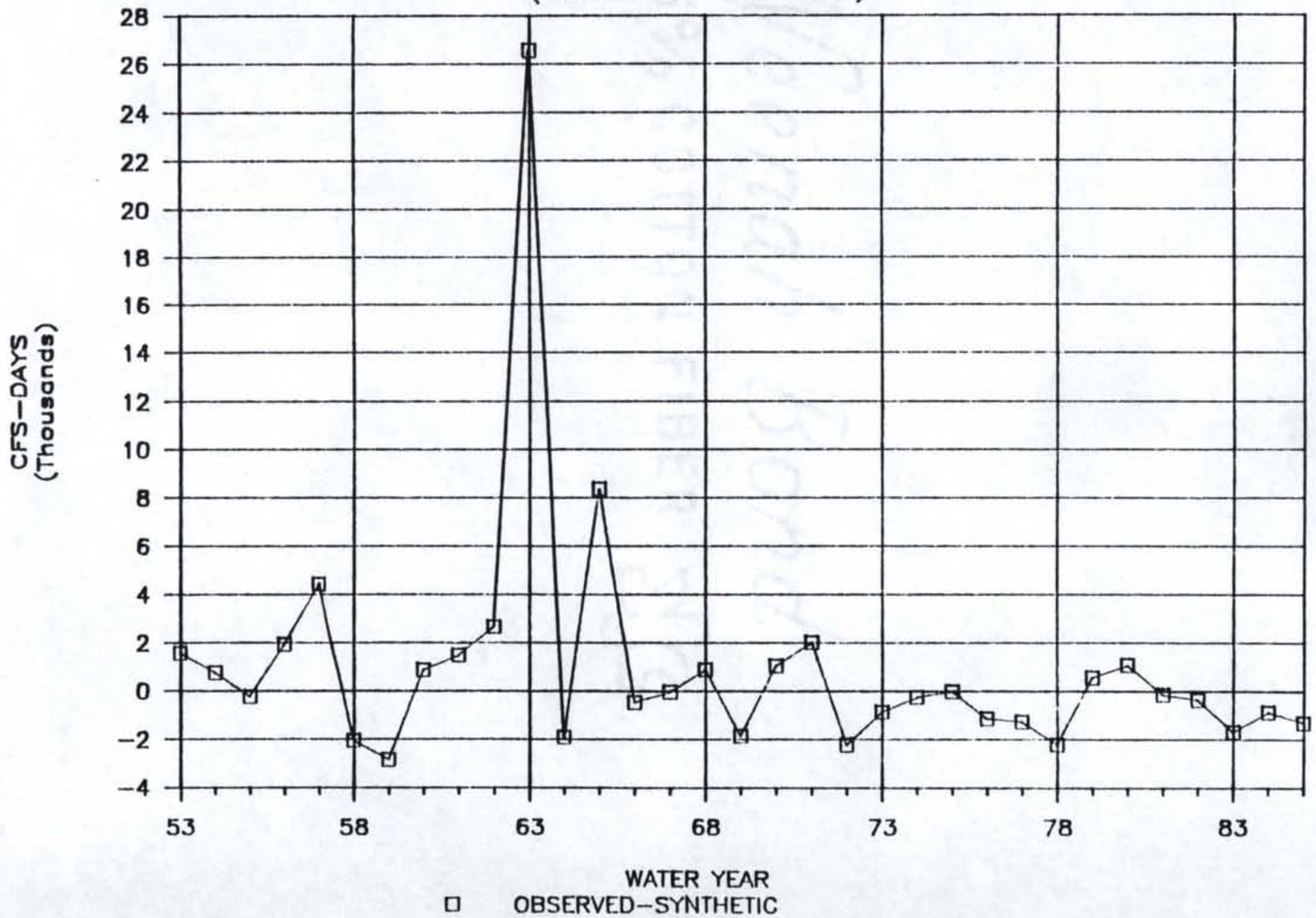
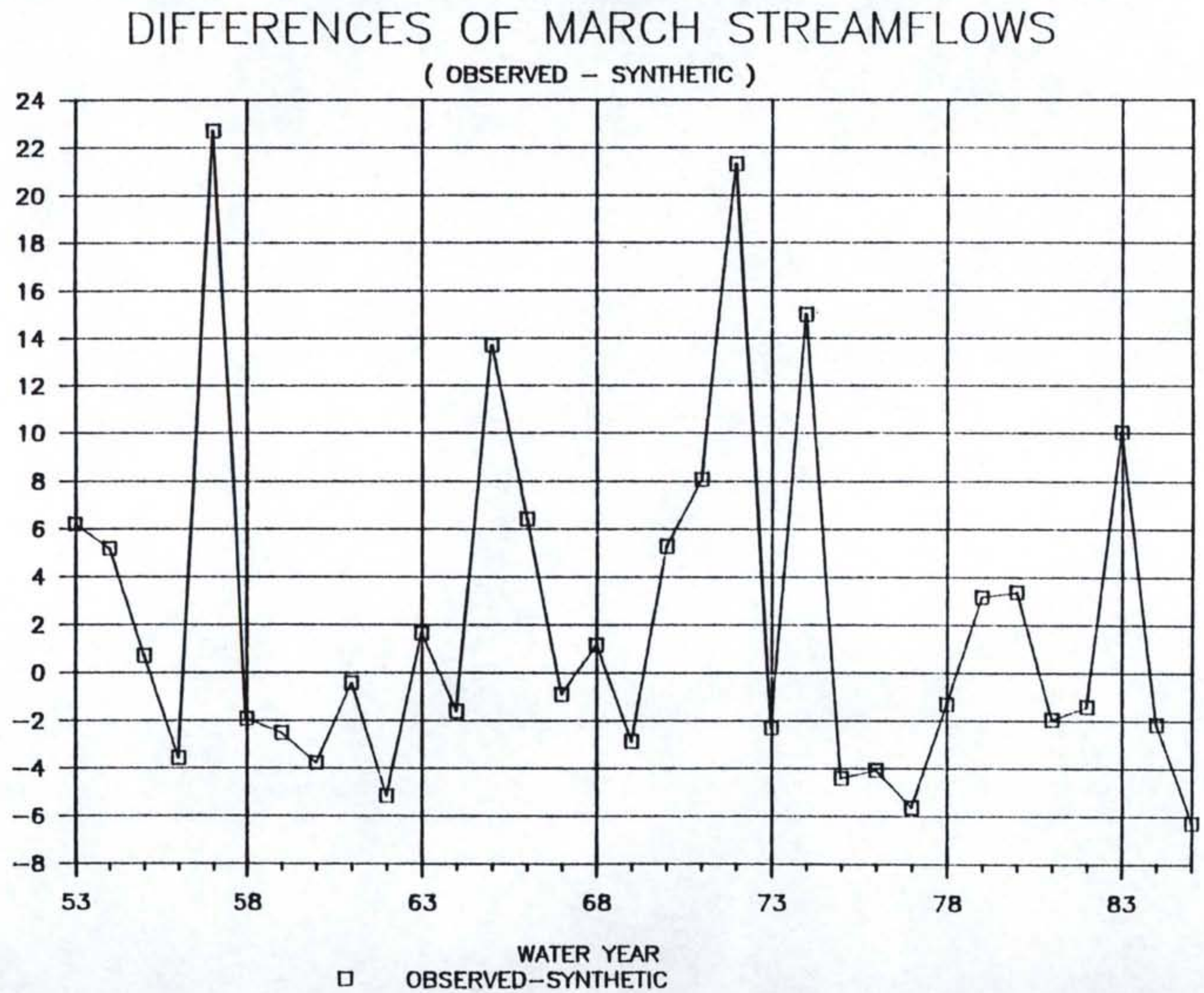


Fig. P.6



DIFFERENCES OF MARCH STREAMFLOWS
(OBSERVED – SYNTHETIC)
CFS–DAYS
(Thousands)
24
22
20
18
16
14
12
10
8
6
4
2
0
–2
–4
–6
–8
53
58
63
68
73
78
83
WATER YEAR
OBSERVED–SYNTHETIC

Fig. P.7

DIFFERENCES OF APRIL STREAMFLOWS

(OBSERVED – SYNTHETIC)

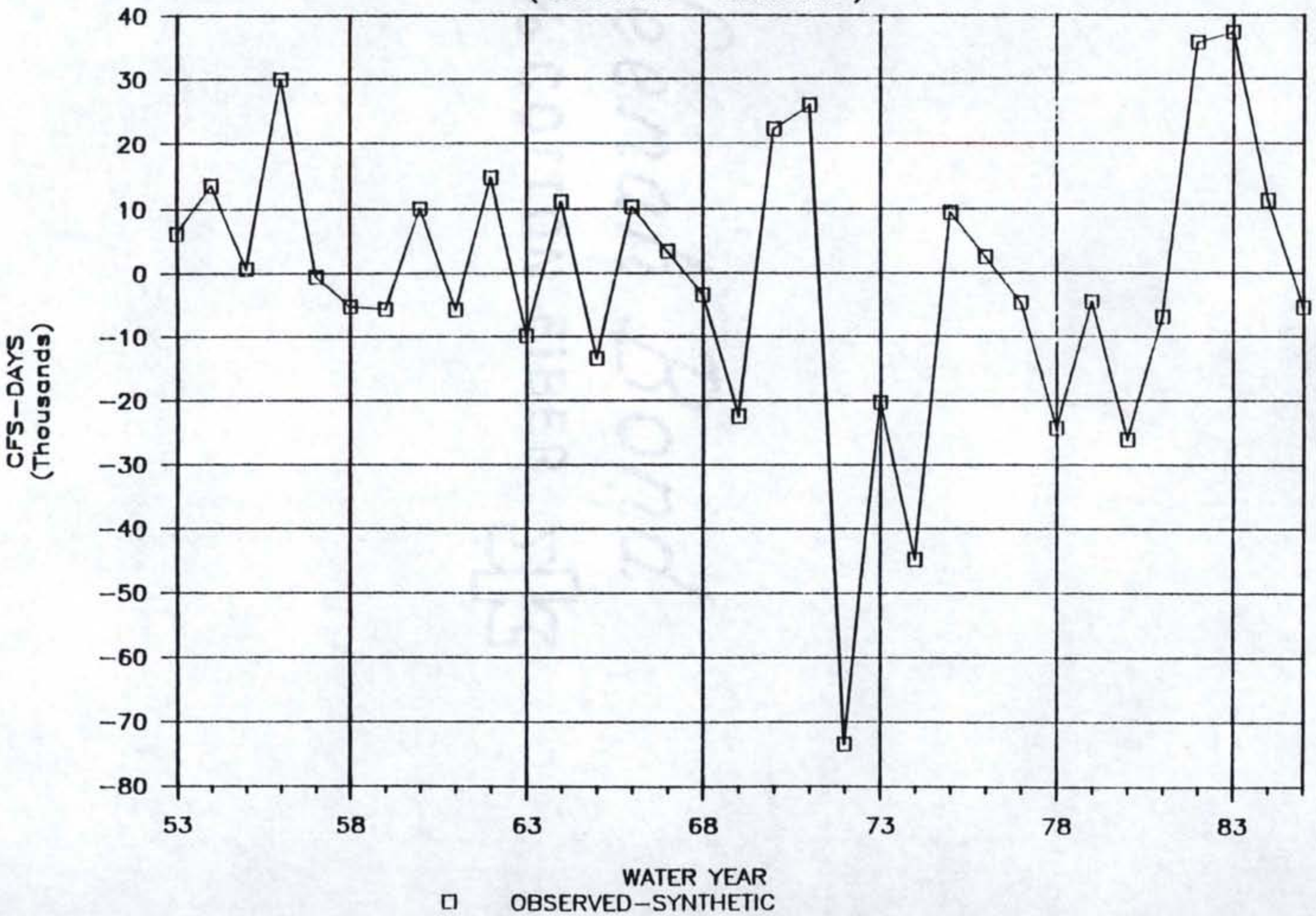


Fig. P.8

DIFFERENCES OF MAY STREAMFLOWS

(OBSERVED – SYNTHETIC)

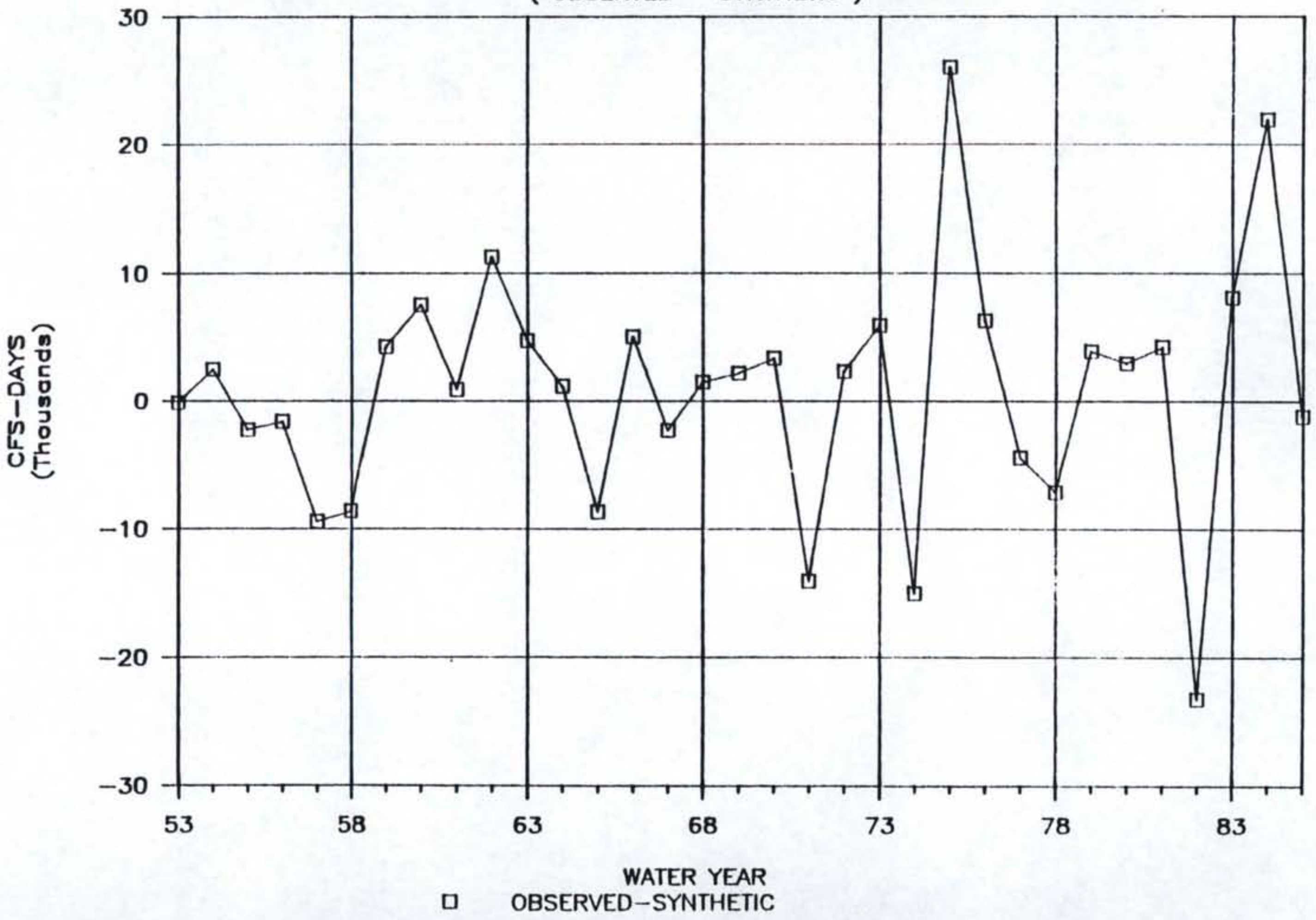


Fig. P.9

DIFFERENCES OF JUNE STREAMFLOWS

(OBSERVED – SYNTHETIC)

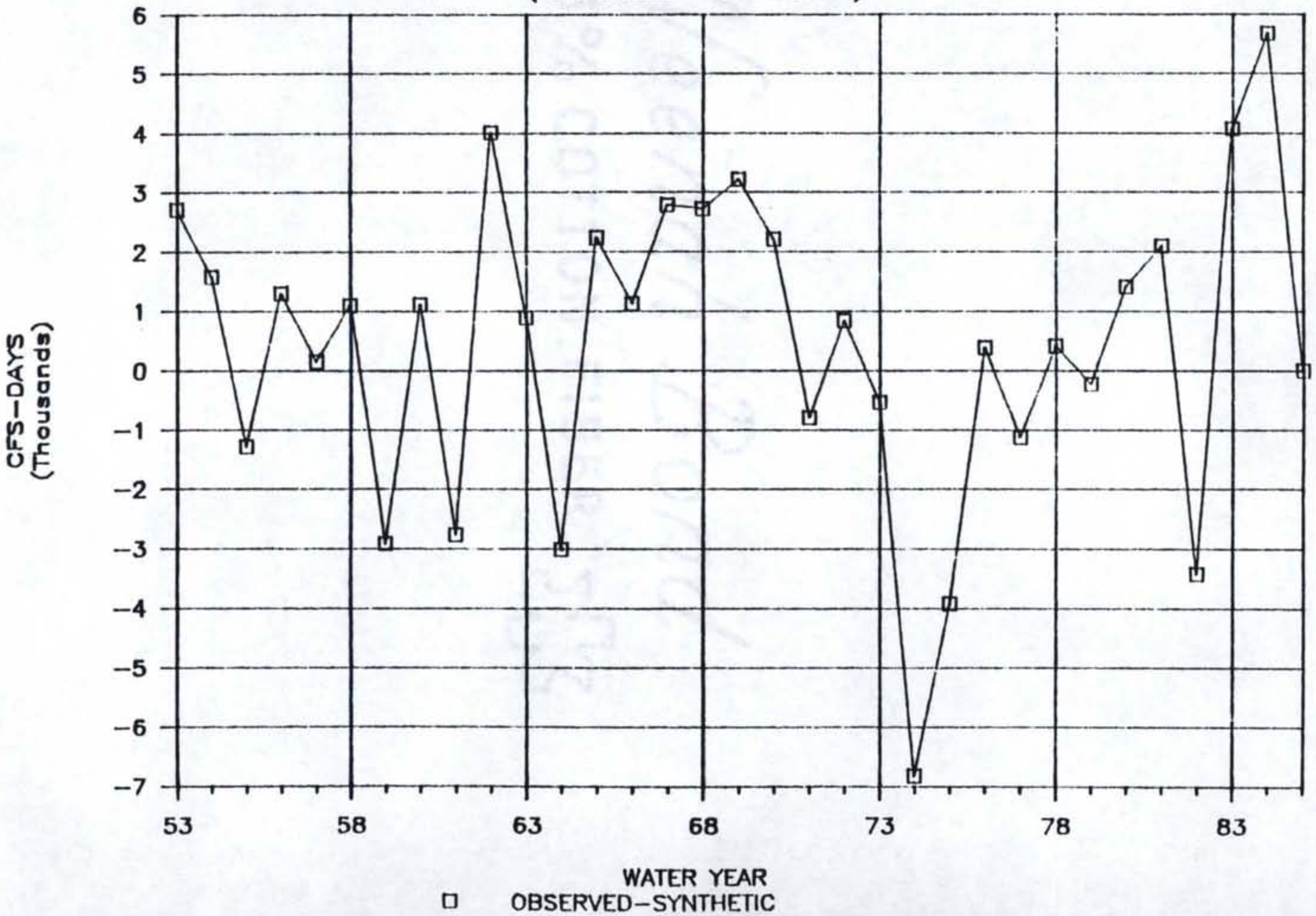


Fig. P.10

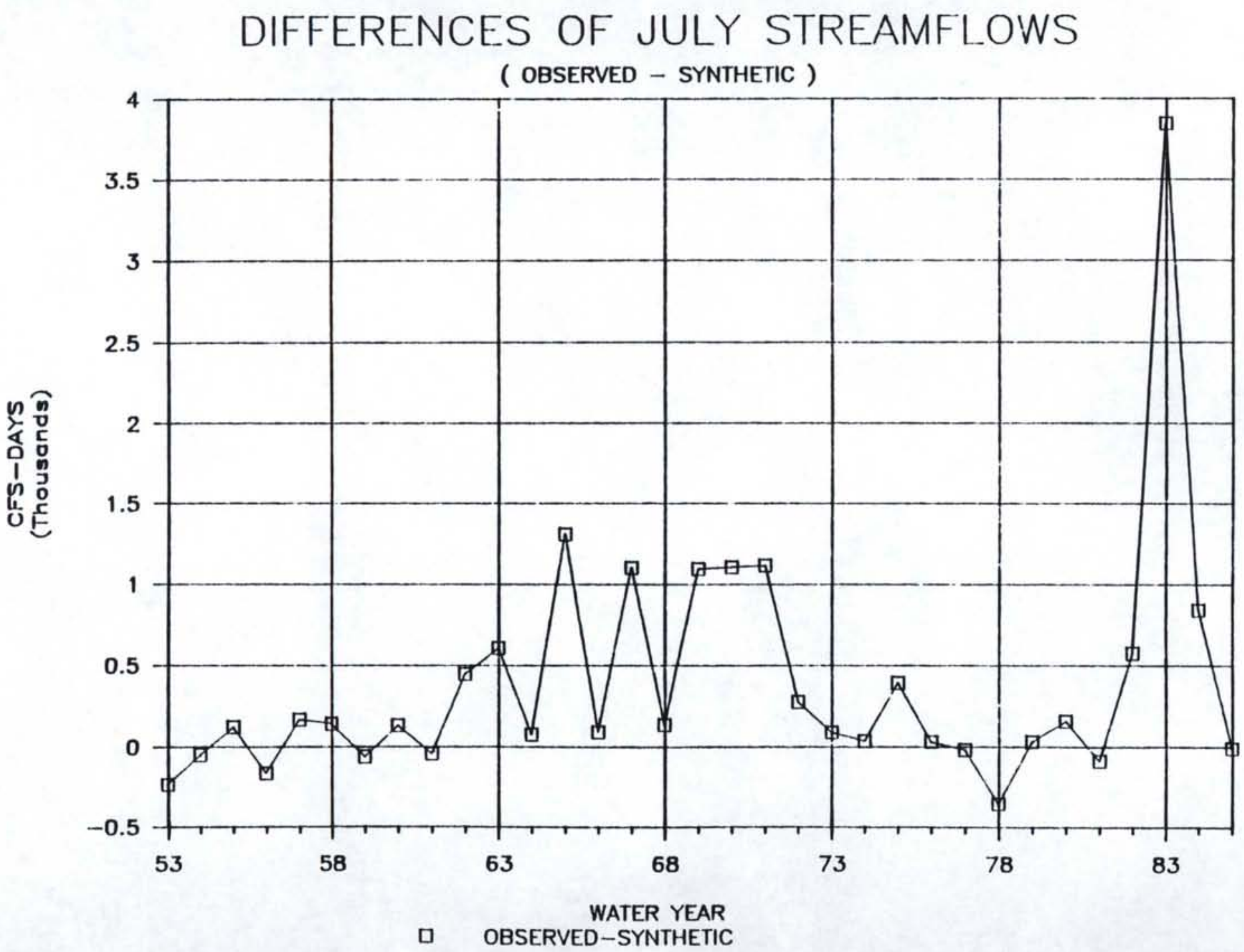

DIFFERENCES OF JULY STREAMFLOWS
(OBSERVED – SYNTHETIC)
CFS–DAYS
(Thousands)
4
3.5
3
2.5
2
1.5
1
0.5
0
–0.5
53
58
63
68
73
78
83
WATER YEAR
OBSERVED–SYNTHETIC

Fig. P.11

DIFFERENCES OF AUGUST STREAMFLOWS

(OBSERVED - SYNTHETIC)

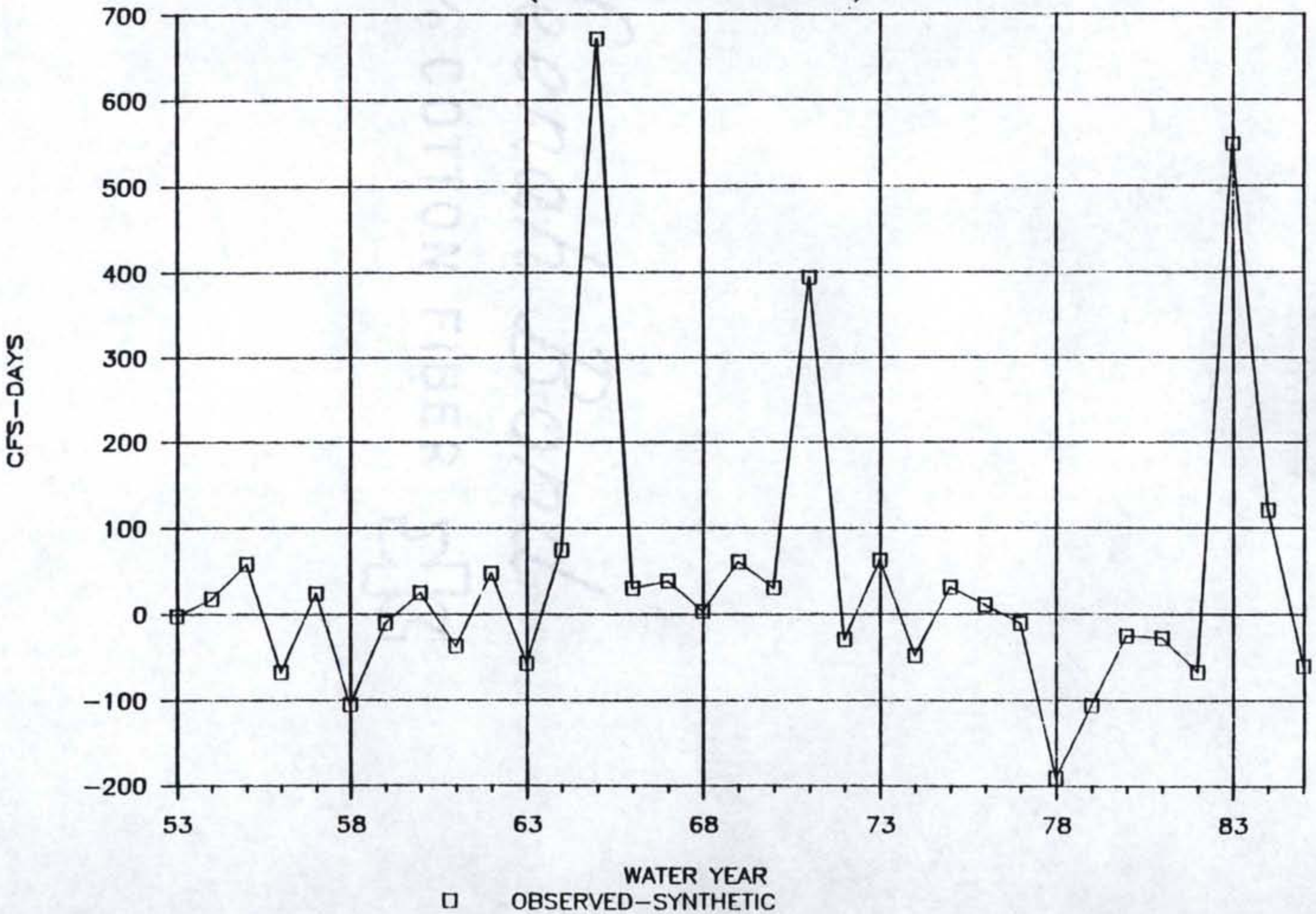
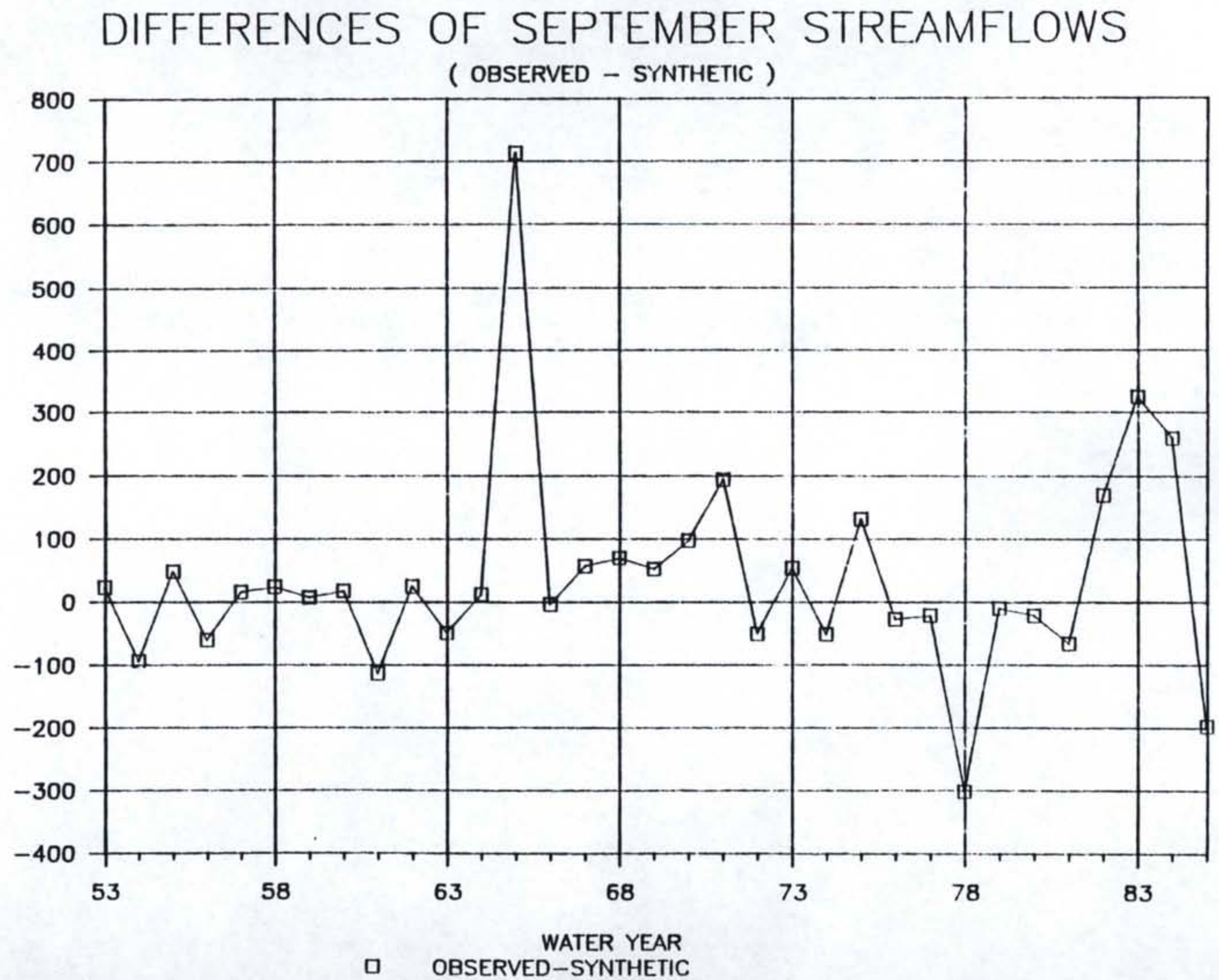


Fig. P.12


DIFFERENCES OF SEPTEMBER STREAMFLOWS
(OBSERVED - SYNTHETIC)
800
700
600
500
400
300
200
100
0
-100
-200
-300
-400
CFS-DAYS
53
58
63
68
73
78
83
WATER YEAR
OBSERVED-SYNTHETIC

APPENDIX Q

LOGS OF IRRIGATION WELLS

IN THE STUDY AREA

Table Q.1

Logs of Irrigation Wells in the Study Area

Project I.D NO.	Well Location	Date Drilled	Depth (feet)	Remarks
1	2S11E	11/04/76	229	
2	2S12E	08/02/77	207	
3	2S12E	11/02/79	597	
4	2S12E	11/09/80	460	
5	2S12E	11/03/80	327	
6	2S12E	11/03/56	266	
7	2S13E	06/24/73	360	
8	2S14E	10/28/53	533	
9	2S14E	06/15/68	364	
10	2S17E	01/05/79	245	
11	2S17E	06/01/65	250	
12	2S17E	11/17/76	410	
13	2S17E	03/30/76	407	
14	2S17E	05/17/53	226	
15	2S17E	07/19/55	100	
16	1S09E	10/21/80	483	
17	1S09E	10/23/76	551	
18	1S12E	07/30/80	200	
19	1S12E	12/15/82	433	
20	1S13E	05/07/77	1125	
21	1S13E	06/06/68	400	
22	1S13E	06/01/73	363	
23	1S13E	11/12/76	415	
24	1S13E	05/27/77	460	
25	1S13E	06/30/73	363	
26	1S13E	12/11/77	500	
27	1S13E	10/24/75	200	Deepened
28	1S13E	08/20/78	155	
29	1S13E	07/30/78	165	
30	1S14E	12/12/76	500	
31	1S14E	07/15/54	535	
32	1S14E	10/31/80	226	Dom. & Irr.
33	1S14E	10/21/74	120	
34	1S14E	01/09/79	356	
35	1S14E	11/06/74	243	
36	1S14E	03/29/78	520	
37	1S14E	12/30/78	535	
38	1S14E	06/15/79	388	
39	1S14E	10/27/76	465	
40	1S14E	06/04/77	355	

Table Q.1 (Continued)

Logs of Irrigation Wells in the Study Area

Project I.D NO.	Well Location	Date Drilled	Depth (feet)	Remarks
41	1S14E	10/24/74	280	
42	1S14E	03/02/79	460	Replacement
43	1S14E	07/07/53	434	
44	1S14E	03/17/78	500	
45	1S14E	06/12/74	202	
46	1S14E	06/17/74	300	
47	1S14E	05/28/75	130	
48	1S14E	01/31/75	98	
49	1S14E	05/10/75	78	
50	1S14E	04/03/78	160	
51	1S15E	08/20/53	480	
52	1S15E	11/29/79	486	
53	1S15E	06/26/74	160	
54	1S15E	04/25/74	185	
55	1S15E	06/20/74	140	
56	1S15E	12/10/76	252	
57	1S15E	01/18/77	196	
58	1S15E	11/20/54	155	Dom. & Irr.
59	1S15E	08/30/53	122	
60	1S15E	10/24/74	222	
61	1S15E	11/17/53	283	
62	1S15E	03/03/78	260	
63	1S15E	02/28/77	345	
64	1S15E	03/06/78	282	
65	1S15E	09/01/79	263	
66	1S15E	11/29/76	345	
67	1S16E	09/08/55	318	
68	1S16E	08/23/55	208	
69	1S17E	06/17/73	160	
70	1S17E	09/30/78	386	Replacement
71	1S17E	12/24/74	135	
72	1N09E	11/29/74	440	
73	1N14E	09/28/77	300	
74	1N14E	06/21/74	280	
75	1N14E	01/19/79	377	
76	1N17E	08/20/67	358	

Table Q.2

Irrigation Well Development History
in the Study Area

Water Year	No. of Irrigation Well Developed	Cumulative No. of Irrigation Well
53	4	4
54	3	7
55	4	11
56	0	11
57	1	12
58	0	12
59	0	12
60	0	12
61	0	12
62	0	12
63	0	12
64	0	12
65	1	13
66	0	13
67	1	14
68	2	16
69	0	16
70	0	16
71	0	16
72	0	16
73	4	20
74	6	26
75	9	35
76	2	37
77	15	52
78	9	61
79	7	68
80	3	71
81	4	75
82	0	75
83	1	76
84	0	76
85	0	76

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