Dworshak Water Supply Forecast

2005 Update to Statistical Forecast Equations

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Summary

New regression equations (the "NWD2005" model) for the Dworshak April-July water supply forecast were developed using principal components regression on all available data updated through 2004. In comparison with the current Corps' forecast model (the "NRCS95" model), similarly recalibrated with updated data, the statistics for the new equations are virtually indistinguishable from the updated NRCS95 model, except that the new 1-Dec forecast model displays a marked improvement over the revisions implemented by Garen in 1995 (Figure 1). Minor adjustments have been made in the station selections for any given forecast date. It is believed that the new station selections provide for equal or slightly improved month-to-month consistency of variables.

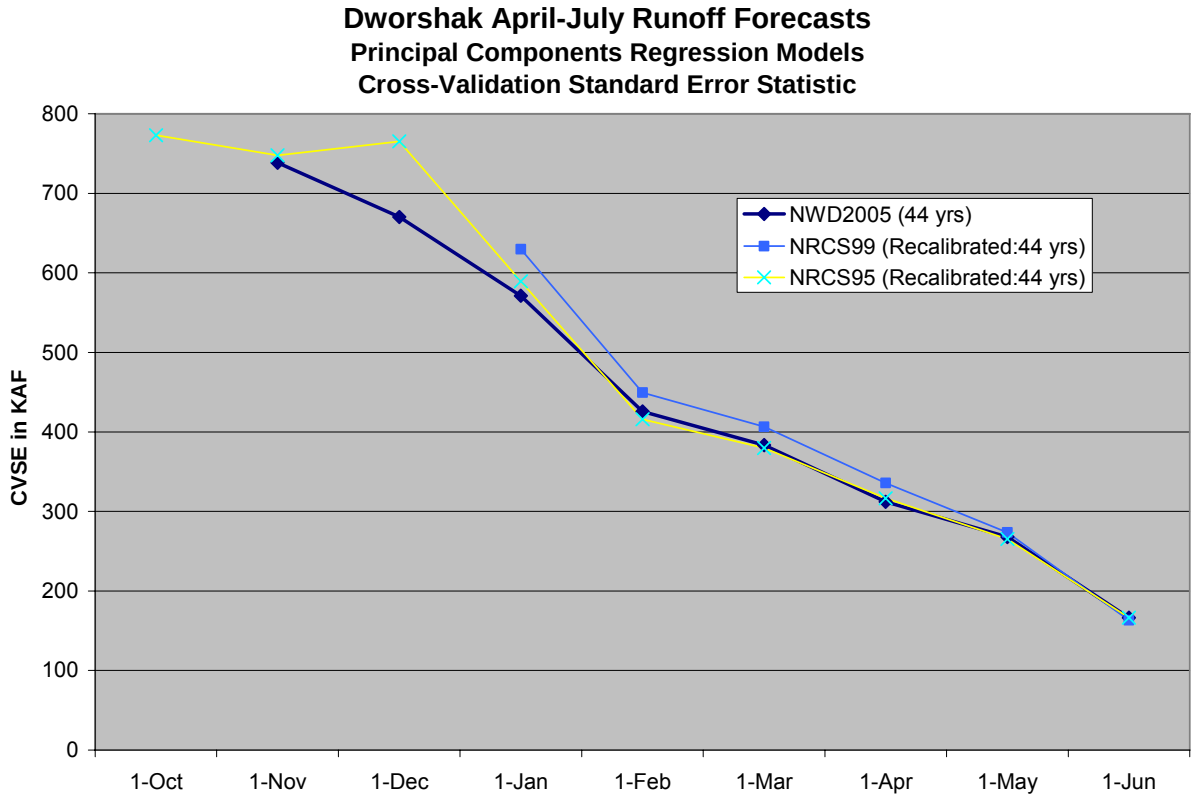

Figure 1 -- Comparison of Dworshak forecast model cross-validation statistics

Historical review of Dworshak forecast models

Seven iterations of statistical forecast models for Dworshak seasonal volume inflows have previously been developed (Garen, 1995 and Moore, 1999). Figure 2 presents an overview of the time frames used in the calibration and recalibration of the most recent models and Figure 3 presents a table summarizing the entire suite of historical models.

The Corps' Walla Walla District developed regression equations fit to individual variables (1977, updated in 1981), with the resulting forecast for each predictor variable averaged across the forecasts. The Northwest River Forecast Center, NOAA, subjectively weighted and combined predictor variables into a single index variable and then fit a regression coefficient to the single index variable (1976, updated in 1985). The NWRFC procedure required use of "normal subsequent" data as surrogates for precipitation and snow data that had yet to be observed. The NRCS utilized their principal components regression procedure to develop one or two principal components for each month and fit regression coefficients to the principal components (1993, updated in 1995 by Garen and further revised in 1999 by Moore). The NRCS models were the first to utilize a climate variable, the Southern Oscillation Index (SOI). The current review includes a recalibration of both the NRCS95 and NRCS99 models, along with development of new equations and variable selections based on the updated dataset.

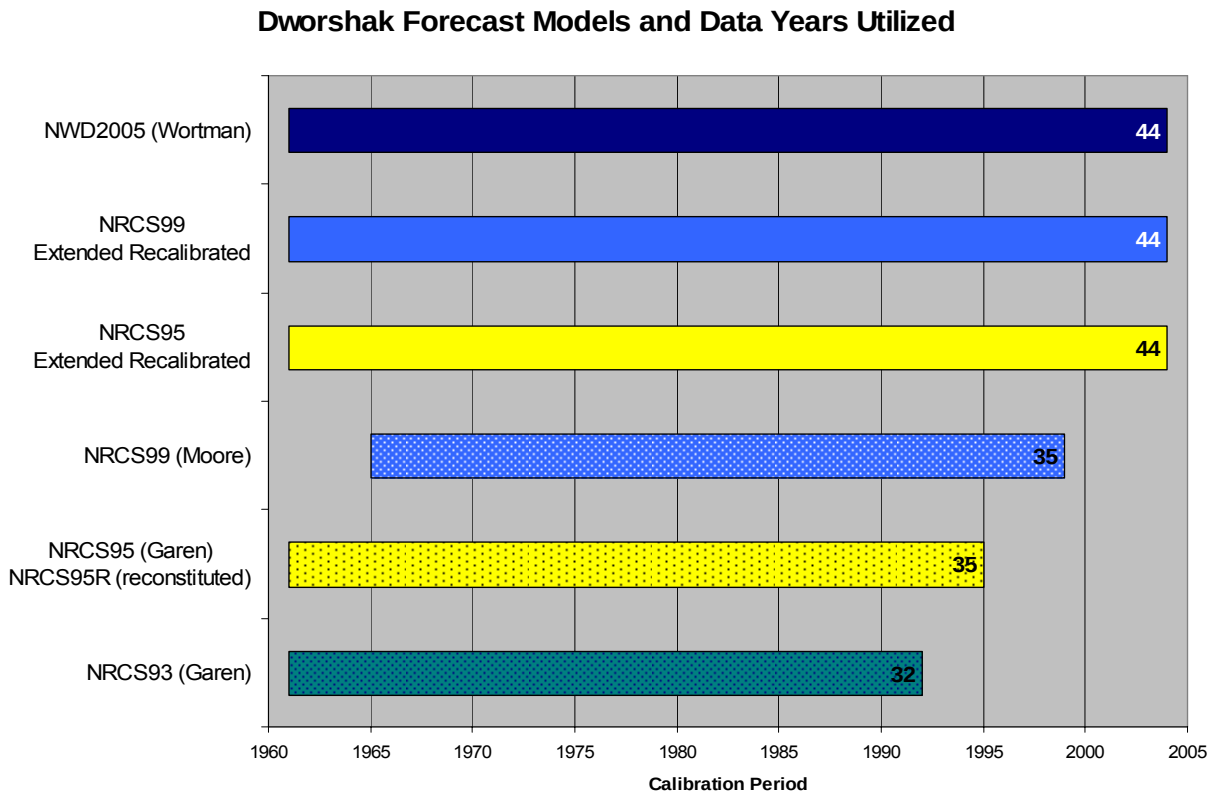

Figure 2--Forecast models, with years used for model calibration

Statistical Forecast Model History

Model Name	Proponent	Date	Activity	Model Type and Details
NWW77	Corps, NWW	1977	Developed; calibrated. 1961-1976?	Mulitple Variable Linear Regression: Regression models are fit to each variable. Forecasts are generated for each equation, with the predictions then averaged across variable type. 1-Jan forecast is average of the two variable type averages.
NWW81	Corps, NWW	1981	Update; recalibrated 1961-1980?	North Star Ranch and Orofino precip stations closed; dropped. Dworshak Fish Hatchery precip station added. Most snow course stations moved to SNOTEL stations.
RFC76	NWSRFC	1976	Developed; calibrated 1961-1975?	Single Variable Regression: Data for Fall streamflow, 1Apr snow, and Nov-Jun precipitation are all weighted and combined into a single index variable used as the predictor variable. Uses monthly weights, station weights, and variable "type" weights. Singl
RFC85	NWSRFC	1985	Update; recalibrated 1961-1984?	Orofino precip station closed; dropped. Dworshak Fish Hatchery added. Snow course stations changed to available SNOTEL stations.
NRCS93	NRCS	1993	Developed; calibrated Dataset:1961-1992	Principal Component Regression Separate equations fit for each month. Uses SOI, precipitation, SWE, and monthly streamflow variables.
NRCS95	NRCS	1995	Recalibrated.1961-1995	November precipitation at Elk River 1S station dropped from 1-Dec forecast.
NRCS99	NRCS	1999	Recalibrated.1965-1999	Dropped 1961-1964 data years. (I don't know why!). Greater utilization of Shanghi Summit and Crater Meadows, less of Hemlock Butte. Greater use of Elk River 1-Dec precip. Revised flow and SOI variables.
NWD2005	Corps, NWD	2005	Developed; calibrated 1961-2004	Principal Component Regression Separate equations fit for each month. Uses SOI, precipitation, SWE, and monthly streamflow variables.

Forecast Variables

Model Name		1-Oct	1-Nov	1-Dec	1-Jan	1-Feb	1-Mar	1-Apr	1-May	1-Jun
NWW77	Predictor:				Precip (8) SWE (8)	SWE (8)	SWE (10)	SWE (10)	SWE (10)	SWE (6)
	Dependent:				Apr-Jul	Apr-Jul	Apr-Jul	Apr-Jul	Apr-Jul	Apr-Jul
NWW81	Predictor:				Precip (7) SWE (8)	SWE (8)	SWE (10)	SWE (10)	SWE (10)	SWE (6)
	Dependent:				Apr-Jul	Apr-Jul	Apr-Jul	Apr-Jul	Apr-Jul	Apr-Jul
RFC76	Predictor:				Fall Q (2) Precip (5) SWE (5)	Fall Q (2) Precip (5) SWE (5)	Fall Q (2) Precip (5) SWE (5)	Fall Q (2) Precip (5) SWE (5)	Fall Q (2) Precip (5) SWE (5)	Fall Q (2) Precip (5) SWE (5)
	Dependent:				Apr-Jul	Apr-Jul	Apr-Jul	Apr-Jul	Apr-Jul	Apr-Jul
RFC85	Predictor:				Fall Q (2) Precip (5) SWE (5)	Fall Q (2) Precip (5) SWE (5)	Fall Q (2) Precip (5) SWE (5)	Fall Q (2) Precip (5) SWE (5)	Fall Q (2) Precip (5) SWE (5)	Fall Q (2) Precip (5) SWE (5)
	Dependent:				Apr-Jul	Apr-Jul	Apr-Jul	Apr-Jul	Apr-Jul	Apr-Jul
NRCS93	Predictor:	SOI (2)	SOI (3)	Precip (2) SOI (4) Precip (1)	Precip (2) SWE (4) SOI (5)	Precip (2) SWE (4) SOI (7) Q (1)	Precip (2) SWE (4) SOI (7) Q (2)	Precip (2) SWE (4) SOI (7) Q (3)	SWE (4) SOI (7) Q (1)	SWE (4) SOI (7)
	Dependent:	Apr-Jul	Apr-Jul	Apr-Jul	Apr-Jul	Apr-Jul	Apr-Jul	Apr-Jul	May-Jul	Jun-Jul
NRCS95	Predictor:	SOI (2)	SOI (3)	SOI (4)	Precip (1) SWE (4) SOI (5)	SWE (4) SOI (6) Q (1)	SWE (4) SOI (6) Q (2)	SWE (4) SOI (6) Q (3)	SWE (4) Q (1)	SWE (4)
	Dependent:	Apr-Jul	Apr-Jul	Apr-Jul	Apr-Jul	Apr-Jul	Apr-Jul	Apr-Jul	May-Jul	Jun-Jul
NRCS99	Predictor:				Precip (1) SWE (5) SOI (4)	Precip (1) SWE (5) SOI (5) Q (1)	Precip (1) SWE (5) SOI (5) Q (1)	Precip (1) SWE (4) SOI (5) Q (2)	SWE (4) SOI (5) Q (1)	SWE (5) Q (1)
	Dependent:	Apr-Jul	Apr-Jul	Apr-Jul	Apr-Jul	Apr-Jul	Apr-Jul	Apr-Jul	May-Jul	Jun-Jul
NWD2005	Predictor:		SOI (1)	Precip (1) SOI (1)	Precip (2) SWE (4) SOI (1)	SWE (4) SOI (1) Q (1)	SWE (5) SOI (1) Q (2)	SWE (5) SOI (1) Q (3)	SWE (4) SOI (1)	SWE (4)
	Dependent:		Apr-Jul	Apr-Jul	Apr-Jul	Apr-Jul	Apr-Jul	Apr-Jul	May-Jul	Jun-Jul

Figure 3--Comparison of historic Dworshak statistical forecast models

Data review

Dworshak inflows were manually computed from USGS gage records and Corps' project data from CROHMS. These computed inflows were compared to the data provided by the NRCS, the CROHMS inflows, and the Year 2000 Modified Flows data computed by BPA. Although there were minor discrepancies among all datasets, the Year 2000 Modified Flows were chosen as the most consistent dataset. The Modified Flow values were used where available, for 1961 through 1999, and were supplemented with CROHMS computed inflows from 2000 through 2004.

Antecedent streamflow values for the months of January through May were included in the pool of possible predictor variables in the principal components regression analysis for the 1-February through 1-June forecasts. Three dependent variables were utilized such that the forecast volume was always subsequent to the forecast date. April-July accumulated inflow volume was utilized as the dependent variable for all forecasts through 1-April. The 1-May forecast was for the May-July inflow volume; the 1-June forecast was for the June-July inflow volume.

The Southern Oscillation Index (SOI) values from the NOAA Climate Prediction Center (http://www.cpc.ncep.noaa.gov/data/indices/soi) for the period 1951-2004 were analyzed to determine candidate climate variables for the statistical model. The SOI data were processed as one-month, two-month, three-month, four-month, and five-month accumulated values and their correlations with Dworshak April-July runoff analyzed. This analysis (Figure 4) shows that the highest correlations (0.63) occurred with any variable containing September SOI, regardless of which nearby months might be accumulated with it. The single-month September SOI was nominated for use in the principal components regression analysis.

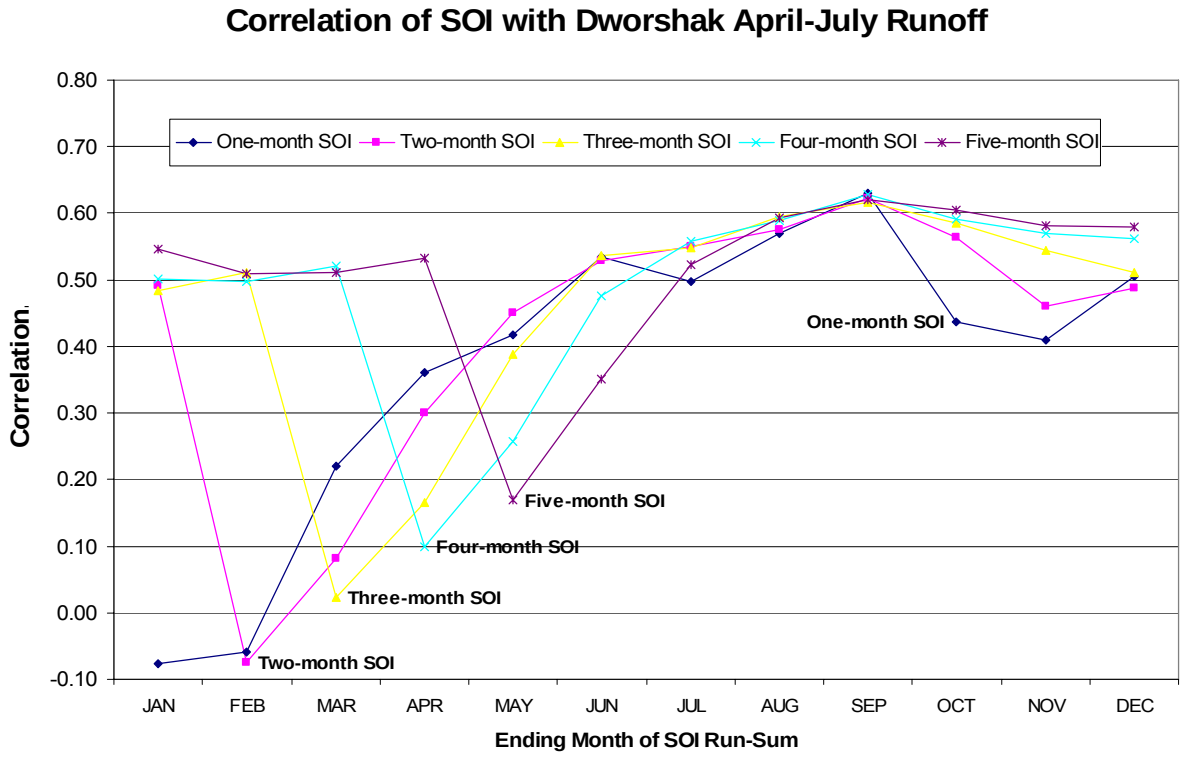

Figure 4 – SOI-Runoff correlation analysis

Data from 19 precipitation stations were reviewed for consideration in the forecast model. Six stations were eliminated as they are no longer open. Dworshak Fish Hatchery was not considered due the station data beginning in Dec 1966. An analysis of the correlations between precipitation stations and Dworshak April-July inflows revealed that only November, December and January precipitation data had significant correlations, with all stations for all months from February through June displaying insignificant and in many cases negative correlations with runoff. Elk River, Headquarters, and Powell were retained for further use in the principal components regression analysis.

Of particular interest is the consideration of a precipitation variable for the 1-December forecast. The initial NRCS 1993 model included Elk River 1S November precipitation in the 1-December forecast. The 1995 review by Garen determined that the unusually large November 1994 precipitation value (216% of normal) at Elk River was largely responsible for the sizeable early-season forecast error, and in hindsight Garen recommended eliminating this station and recalibrating the 1-December forecast equation without a precipitation variable. This current analysis, with considerable additional data available, determines that the Headquarters precipitation station is better correlated with the Dworshak April-July runoff volume than the Elk River station, and that Headquarters is much more representative of the basin precipitation in November 1994 than the Elk River station (Headquarters, at 161% of normal, is among four stations reporting between 155% and 166% of normal). This analysis includes the Headquarters November precipitation station in the 1-December forecast equation.

Seven snow stations were located in the region near Dworshak reservoir. Due to the absence of late season snow, only six stations have non-zero data for 1-May and five stations have non-zero data for 1-June. All available snow stations were included in the principal components regression analysis.

Fifty-two monthly variables were tabulated and forwarded for use in the principal components regression analysis utilizing data from 1961 to 2004 (44 years). When filtered to consider only those variables actually available on a forecast date, and further restricted to consider only the most recently observed snow data (except for the 1-June forecast when both 1-May and 1-June snow data are both allowed to be considered), a subset of usually less than a dozen variables is included in the variable pool considered for any given forecast date.

Corps' NWD 2005 Forecast Models

First-of-month regression models were fit to the 44 years of available data (1961-2004) utilizing the NRCS principal components regression model in accordance with the guidelines provided by the NRCS (Garen, 2004). The NRCS95 and NRCS99 models were also recalibrated using the same 44 year dataset.

The resulting NWD2005 model is quite similar to the NRCS95 model. Both the NWD2005 and recalibrated NRCS95 models are superior to the recalibrated NRCS99 model. The NWD2005 model utilizes a single-month (September) SOI variable whereas both previous NRCS models used various multi-month aggregated SOI variables. The precipitation station changed from Elk

River to Headquarters, and the use of a precipitation variable for the 1-December forecast equation (introduced in the NRCS93 model, but removed in the NRCS95 revisions) is reinstated. The Shanghai Summit snow station is no longer used and the Lost Lake and Pierce snow stations are utilized in more months than in the previous equations. Four snow stations remain unchanged.

Figure 5 provides the summary statistics for the new NWD2005 equations. The regression coefficients for the original data variables in the NWD2005 model are provided in Figure 6. Detailed comparisons of the model statistics and variables used in the two recent NRCS models and the NWD2005 models are presented in Figures 7-11.

Corps NWD 2005 Model Summary								
	1-Nov	1-Dec	1-Jan	1-Feb	1-Mar	1-Apr	1-May	1-Jun
Standard Deviation of Runoff Vol.	896	*896*	*896*	*896*	*896*	*896*	*782*	*483*
Cross-Validation Standard Error	739	670	571	426	383	312	268	166
Standard Error	703	638	533	408	367	298	254	155
R-square (adjusted for DF)	0.384	0.494	0.646	0.793	0.833	0.890	0.894	0.904
Number of years of data	44	44	44	44	44	44	44	38
Number of variables	1	2	7	6	8	9	5	4
Number of Principal Components	1	1	2	1	1	1	1	1

Figure 5 – Summary statistics for the NWD2005 equations

Regression Coefficients for NWD 2005 Dworshak Forecast Equations										
						Forecast Date				
Variable	Type	Observation Date	1-Nov	1-Dec	1-Jan	1-Feb	1-Mar	1-Apr	1-May	1-Jun
SOI	Climate	Sep	511.73	344.40	271.68	108.05	90.47	95.93	103.45	
Headquarters	Precip	Nov		182.715	99.827					
Headquarters	Precip	Dec			45.827					
Elk Butte	Snow	First-of-Month			9.769	19.168	12.426	12.913	12.892	8.347
Hemlock	Snow	First-of-Month			12.046	17.270	13.024	13.201	11.591	7.450
Hoodoo	Snow	First-of-Month			13.611	19.132	13.194	12.456	11.712	7.882
PierceJan	Snow	First-of-Month			35.139	48.512	30.913	26.078		
LostLk	Snow	First-of-Month					9.997	9.215	9.197	5.703
DWR_Jan	Streamflow	Jan				0.895	0.800	0.745		
DWR_Feb	Streamflow	Feb					0.125	0.120		
DWR_Mar	Streamflow	Mar						0.321		
Intercept			2641.5	1734.6	1095.6	413.1	169.0	-179.8	-149.9	198.6

Figure 6 -- Regression coefficients for the NWD2005 equations

Forecast CVSE								
	1-Nov	**1-Dec**	**1-Jan**	**1-Feb**	**1-Mar**	**1-Apr**	**1-May**	**1-Jun**
NRCS99 1965-1999 (N=35) Orig			579.8	448.0	381.5	328.6	277.7	183.0
NRCS99 1965-1999 (N=35) reconstructed			*584.1*	*448.6*	*397.0*	*349.4*	*285.4*	*173.3*
NRCS99 1961-2004 (N=44) *reconstructed, extended*			629.7	449.4	406.5	335.8	273.5	163.0
NRCS95/COE (N=35) "Official Corps' Forecast"	**698.0**	**710.4**	**566.6**	**422.0**	**355.3**	**275.5**	**259.1**	**159.5**
NRCS95 extended, recalibrated (N=44)	747.8	765.4	589.3	415.8	379.9	316.6	265.3	166.3
NWD2005 1961-2004 (N=44)	**738.5**	**670.3**	**571.1**	**425.7**	**383.3**	**312.1**	**267.9**	**166.3**
Standard Deviation	*895.8*	*895.8*	*895.8*	*895.8*	*895.8*	*895.8*	*781.5*	*482.7*

NRCS 1995 Models ("Official Corps Forecasts")				(1961-1995 data)				
Variable	**1-Nov**	**1-Dec**	**1-Jan**	**1-Feb**	**1-Mar**	**1-Apr**	**1-May**	**1-Jun**
Dependent Var Season	*Apr-Jul*	*Apr-Jul*	*Apr-Jul*	*Apr-Jul*	*Apr-Jul*	*Apr-Jul*	*May-Jul*	*Jun-Jul*
SOI	Jul-Sep	Jul-Oct	Jul-Nov	Jul-Dec	Jul-Dec	Jul-Dec		
Headquarters, ID Precip								
Elk River 1S, ID Precip			Dec					
Pierce, ID SWE			1-Jan	1-Feb	1-Mar			
Hoodoo, ID SWE			1-Jan	1-Feb	1-Mar	1-Apr	1-May	1-Jun
Elk Butte, ID SWE			1-Jan	1-Feb	1-Mar	1-Apr	1-May	1-Jun
Shanghai, ID SWE						1-Apr	1-May	
Crater Meadows, ID SWE								
Hemlock, ID SWE			1-Jan	1-Feb	1-Mar	1-Apr	1-May	1-Jun
Lost Lake, ID SWE								1-Jun
Dworshak Inflow				Jan	Jan, Feb	Jan, Feb, Mar	Apr	
Number of Variables	1	1	6	6	7	8	5	4
Number of PrinComps	1	1	2	1	1	1	1	1
CVSE	698.0	710.4	566.6	422.0	355.3	275.5	259.1	159.5

Corps 2005 Models		(1961-2004 data)						
Variable	**1-Nov**	**1-Dec**	**1-Jan**	**1-Feb**	**1-Mar**	**1-Apr**	**1-May**	**1-Jun**
Dependent Var Season	*Apr-Jul*	*Apr-Jul*	*Apr-Jul*	*Apr-Jul*	*Apr-Jul*	*Apr-Jul*	*May-Jul*	*Jun-Jul*
SOI	Sep	Sep	Sep	Sep	Sep	Sep	Sep	
Headquarters, ID Precip		Nov	Nov, Dec					
Pierce, ID SWE			1-Jan	1-Feb	1-Mar	1-Apr		
Hoodoo, ID SWE			1-Jan	1-Feb	1-Mar	1-Apr	1-May	1-Jun
Elk Butte, ID SWE			1-Jan	1-Feb	1-Mar	1-Apr	1-May	1-Jun
Hemlock, ID SWE			1-Jan	1-Feb	1-Mar	1-Apr	1-May	1-Jun
Lost Lake, ID SWE					1-Mar	1-Apr	1-May	1-Jun
Dworshak Inflow				Jan	Jan, Feb	Jan, Feb, Mar		
Number of Variables	1	2	7	6	8	9	5	4
Number of PrinComps	1	1	2	1	1	1	1	1
CVSE	738.5	670.3	571.1	425.7	383.3	312.2	267.9	166.3

Figure 7 – Comparison of NRCS 1995 and NWD 2005 models

		1-Jan			1-Feb			1-Mar			1-Apr			1-May			1-Jun		
		N95	N99	C05	N95	N99	C05	N95	N99	C05	N95	N99	C05	N95	N99	C05	N95	N99	C05
Climate_SOI																			
SOI_Jul	Jul	X			X			X			X								
SOI_Aug	Aug	X	X		X	X		X	X		X	X			X				
SOI_Sep	Sep	X	X	**X**	X	X	**X**	X	X	**X**	X	X	**X**		X	**X**			
SOI_Oct	Oct	X	X		X	X		X	X		X	X			X				
SOI_Nov	Nov	X	X		X	X		X	X		X	X			X				
SOI_Dec	Dec				X	X		X	X		X	X			X				
Precipitation																			
ElkRiverDecPpt	Dec	X	X			X			X			X							
ElkRiverJanPpt	Jan																		
HQSNovPpt	Nov			**X**															
HQSDecPpt	Dec			**X**															
HQSJanPpt	Jan																		
POWDecPpt	Dec																		
POWJanPpt	Jan																		
Snow																			
ElkButteJan	Jan	X	X	**X**															
ElkButteFeb	Feb				X	X	**X**												
ElkButteMar	Mar							X	X	**X**									
ElkButteApr	Apr										X	X	**X**						
ElkButteMay	May													X	X	**X**		X	
ElkButteJun	Jun																X		**X**
HemlockJan	Jan	X		**X**															
HemlockFeb	Feb				X		**X**												
HemlockMar	Mar							X		**X**									
HemlockApr	Apr										X		**X**						
HemlockMay	May													X		**X**			
HemlockJun	Jun																X	X	**X**
HoodooJan	Jan	X	X	**X**															
HoodooFeb	Feb				X	X	**X**												
HoodooMar	Mar							X	X	**X**									
HoodooApr	Apr										X	X	**X**						
HoodooMay	May													X	X	**X**			
HoodooJun	Jun																X	X	**X**
PierceJan	Jan	X	X	**X**															
PierceFeb	Feb				X	X	**X**												
PierceMar	Mar							X	X	**X**									
PierceApr	Apr												**X**						
ShanghiJan	Jan		X																
ShanghiFeb	Feb					X													
ShanghiMar	Mar								X										
ShanghiApr	Apr										X	X							
ShanghiMay	May													X	X			X	
LostLkJan	Jan																		
LostLkFeb	Feb																		
LostLkMar	Mar									**X**									
LostLkApr	Apr												**X**						
LostLkMay	May															**X**			
LostLkJun	Jun																X	X	**X**
CraterJan	Jan		X																
CraterFeb	Feb					X													
CraterMar	Mar								X										
CraterApr	Apr											X							
CraterMay	May														X				
CraterJun	Jun																		
Streamflow																			
DWR_Jan	Jan Flow				X	X	**X**	X	X	**X**	X	X	**X**		X			X	
DWR_Feb	Feb Flow							X		**X**	X		**X**						
DWR_Mar	Mar Flow										X	X	**X**						
DWR_Apr	Apr Flow													X		**X**			
DWR_May	May Flow																		**X**

Figure 8 – Matrix comparison of variables in NRCS 1995, NRCS 1999, and Corps NWD 2005 models

		NRCS95	NRCS95	NRCS95	NRCS95	NRCS95	NRCS95	NRCS95	NRCS95	NRCS95
		1-Oct	1-Nov	1-Dec	1-Jan	1-Feb	1-Mar	1-Apr	1-May	1-Jun
Intercept		2690	2667	2687	1539	540	369	-168	-201	183
Climate_SOI										
SOI_Jul	Jul	Σ	Σ	Σ	Σ	Σ	Σ	Σ		
SOI_Aug	Aug	276.4	Σ	Σ	Σ	Σ	Σ	Σ		
SOI_Sep	Sep		191.5	Σ	Σ	Σ	Σ	Σ		
SOI_Oct	Oct			144.2	Σ	Σ	Σ	Σ		
SOI_Nov	Nov				89.7	Σ	Σ	Σ		
SOI_Dec	Dec					20.3	21.8	22.6		
Precipitation										
ElkRiverDecPpt	Dec				17.1					
ElkRiverJanPpt	Jan									
HQSNovPpt	Nov									
HQSDecPpt	Dec									
HQSJanPpt	Jan									
POWDecPpt	Dec									
POWJanPpt	Jan									
Snow										
ElkButteJan	Jan				12.7					
ElkButteFeb	Feb					18.6				
ElkButteMar	Mar						14.2			
ElkButteApr	Apr							15.1		
ElkButteMay	May								14.1	
ElkButteJun	Jun									8.2
HemlockJan	Jan				15.3					
HemlockFeb	Feb					15.6				
HemlockMar	Mar						14.7			
HemlockApr	Apr							15.4		
HemlockMay	May								12.3	
HemlockJun	Jun									7.3
HoodooJan	Jan				13.3					
HoodooFeb	Feb					18.5				
HoodooMar	Mar						15.5			
HoodooApr	Apr							14.6		
HoodooMay	May								12.6	
HoodooJun	Jun									8.4
PierceJan	Jan				63.3					
PierceFeb	Feb					44.1				
PierceMar	Mar						33.4			
PierceApr	Apr									
ShanghiJan	Jan									
ShanghiFeb	Feb									
ShanghiMar	Mar									
ShanghiApr	Apr							15.9		
ShanghiMay	May								13.9	
LostLkJan	Jan									
LostLkFeb	Feb									
LostLkMar	Mar									
LostLkApr	Apr									
LostLkMay	May									
LostLkJun	Jun									5.7
CraterJan	Jan									
CraterFeb	Feb									
CraterMar	Mar									
CraterApr	Apr									
CraterMay	May									
CraterJun	Jun									
Streamflow										
DWR_Jan	Jan Flow					0.8	0.9	0.8		
DWR_Feb	Feb Flow						0.2	0.3		
DWR_Mar	Mar Flow							0.3		
DWR_Apr	Apr Flow								0.3	
DWR_May	May Flow									

Figure 9 -- Variables and regression coefficients in NRCS 1995 model

		NRCS99	NRCS99	NRCS99	NRCS99	NRCS99	NRCS99	NRCS99	NRCS99	NRCS99
		1-Oct	1-Nov	1-Dec	1-Jan	1-Feb	1-Mar	1-Apr	1-May	1-Jun
Intercept					1584.332	296.224	217.260	-137.028	162.928	-6.552
Climate_SOI										
SOI_Jul	Jul									
SOI_Aug	Aug				Σ	Σ	Σ	Σ	Σ	
SOI_Sep	Sep				Σ	Σ	Σ	Σ	Σ	
SOI_Oct	Oct				Σ	Σ	Σ	Σ	Σ	
SOI_Nov	Nov				120.556	Σ	Σ	Σ	Σ	
SOI_Dec	Dec					21.122	23.097	26.982	25.729	
Precipitation										
ElkRiverDecPpt	Dec				27.842	35.133	34.779	39.979		
ElkRiverJanPpt	Jan									
HQSNovPpt	Nov									
HQSDecPpt	Dec									
HQSJanPpt	Jan									
POWDecPpt	Dec									
POWJanPpt	Jan									
Snow										
ElkButteJan	Jan				9.715					
ElkButteFeb	Feb					15.296				
ElkButteMar	Mar						11.823			
ElkButteApr	Apr							13.903		
ElkButteMay	May								12.242	6.914
ElkButteJun	Jun									
HemlockJan	Jan									
HemlockFeb	Feb									
HemlockMar	Mar									
HemlockApr	Apr									
HemlockMay	May									
HemlockJun	Jun									5.664
HoodooJan	Jan				9.286					
HoodooFeb	Feb					15.064				
HoodooMar	Mar						12.522			
HoodooApr	Apr							13.293		
HoodooMay	May								10.806	
HoodooJun	Jun									5.909
PierceJan	Jan				56.245					
PierceFeb	Feb					40.952				
PierceMar	Mar						30.426			
PierceApr	Apr									
ShanghiJan	Jan				14.638					
ShanghiFeb	Feb					20.553				
ShanghiMar	Mar						16.237			
ShanghiApr	Apr							15.583		
ShanghiMay	May								12.515	7.101
LostLkJan	Jan									
LostLkFeb	Feb									
LostLkMar	Mar									
LostLkApr	Apr									
LostLkMay	May									
LostLkJun	Jun									4.342
CraterJan	Jan				12.759					
CraterFeb	Feb					14.071				
CraterMar	Mar						12.830			
CraterApr	Apr							14.434		
CraterMay	May								11.126	
CraterJun	Jun									
Streamflow										
DWR_Jan	Jan Flow					0.725	0.748	0.816	0.816	0.489
DWR_Feb	Feb Flow									
DWR_Mar	Mar Flow							0.422		
DWR_Apr	Apr Flow									
DWR_May	May Flow									

Figure 10 -- Variables and regression coefficients in NRCS 1999 model

		NWD2005	NWD2005	NWD2005	NWD2005	NWD2005	NWD2005	NWD2005	NWD2005	NWD2005
		1-Oct	1-Nov	1-Dec	1-Jan	1-Feb	1-Mar	1-Apr	1-May	1-Jun
Intercept				1734.55	1095.649	413.051	169.000	-179.797	-149.911	198.613
Climate_SOI										
SOI_Jul	Jul									
SOI_Aug	Aug									
SOI_Sep	Sep			344.404	271.684	108.047	90.466	95.929	103.446	
SOI_Oct	Oct									
SOI_Nov	Nov									
SOI_Dec	Dec									
Precipitation										
ElkRiverDecPpt	Dec									
ElkRiverJanPpt	Jan									
HQSNovPpt	Nov			182.715	99.827					
HQSDecPpt	Dec				45.827					
HQSJanPpt	Jan									
POWDecPpt	Dec									
POWJanPpt	Jan									
Snow										
ElkButteJan	Jan				9.769					
ElkButteFeb	Feb					19.568				
ElkButteMar	Mar						12.426			
ElkButteApr	Apr							12.913		
ElkButteMay	May								12.892	
ElkButteJun	Jun									8.347
HemlockJan	Jan				12.046					
HemlockFeb	Feb					17.270				
HemlockMar	Mar						13.024			
HemlockApr	Apr							13.201		
HemlockMay	May								11.591	
HemlockJun	Jun									7.45
HoodooJan	Jan				13.611					
HoodooFeb	Feb					19.132				
HoodooMar	Mar						13.194			
HoodooApr	Apr							12.456		
HoodooMay	May								11.712	
HoodooJun	Jun									7.882
PierceJan	Jan				35.139					
PierceFeb	Feb					48.512				
PierceMar	Mar						30.913			
PierceApr	Apr							26.078		
ShanghiJan	Jan									
ShanghiFeb	Feb									
ShanghiMar	Mar									
ShanghiApr	Apr									
ShanghiMay	May									
LostLkJan	Jan									
LostLkFeb	Feb									
LostLkMar	Mar						9.997			
LostLkApr	Apr							9.215		
LostLkMay	May								9.197	
LostLkJun	Jun									5.703
CraterJan	Jan									
CraterFeb	Feb									
CraterMar	Mar									
CraterApr	Apr									
CraterMay	May									
CraterJun	Jun									
Streamflow										
DWR_Jan	Jan Flow					0.895	0.800	0.745		
DWR_Feb	Feb Flow						0.125	0.120		
DWR_Mar	Mar Flow							0.321		
DWR_Apr	Apr Flow								1.0000	1.0000
DWR_May	May Flow									1.0000

Figure 11 -- Variables and regression coefficients in Corps NWD 2005 model

References

BPA, “Modified Flows – Seasonal Volumes and Statistics”, Year 2000 Update, File “DWR4MST.xls”, electronic media, Bonneville Power Administration, dated 12 Dec 2003.

Garen, David C., “Dworshak Reservoir Inflow Forecast Comparison Study”, a report to the Columbia River Water Management Group. Nov. 1995.

Garen, David C., “Guidelines for Development of Statistical Streamflow Forecasting Models”, National Water and Climate Center, National Resources Conservation Service, USDA, Portland, OR. July 2004

Moore, Daniel, Unpublished PCREG output and spreadsheet files of NRCS 1999 Dworshak forecast update. Natural Resources Conservation Service, Portland, OR. Nov 1999.

Appendix: NWD 2005 Models - PCREG Model Output

PCREG run on 30-Aug-05 at 11:43
JACKKNIFE REGRESSION PROGRAM

Input data from file: PCREG_temp.txt

VARIABLES:

  Y1   Dwr_AprJul Dworshak Apr-Jul Runoff in KAF

  X1   SOI_SepSeptember SOI

REGRESSION EQUATION:

var	coef
X1	511.726
C	2641.518

#obs= 44
#pc = 1
 jr = 0.582
jse = 738.466
  r = 0.631
 se = 703.262

YEAR	OBSERVED	JCK REG COMPUTED	JCK REG ERROR	STD REG COMPUTED	STD REG ERROR
1961	2900.00	3003.11	103.11	2999.73	99.73
1962	3035.60	2684.60	-351.00	2692.69	-342.91
1963	1804.30	2928.90	1124.60	2897.38	1093.08
1964	3406.20	2246.96	-1159.24	2283.31	-1122.89
1965	3310.00	3361.08	51.08	3357.93	47.93
1966	2149.80	1855.04	-294.76	1873.93	-275.87
1967	2693.30	2482.92	-210.38	2488.00	-205.30
1968	1975.40	2978.89	1003.49	2948.55	973.15
1969	2878.70	2478.33	-400.37	2488.00	-390.70
1970	2622.60	1996.81	-625.79	2027.45	-595.15
1971	4050.80	3262.36	-788.44	3306.76	-744.04
1972	4688.90	3363.22	-1325.68	3460.28	-1228.62
1973	1262.40	1864.86	602.46	1822.76	560.36
1974	4759.90	3265.95	-1493.95	3357.93	-1401.97
1975	3342.20	3304.65	-37.55	3306.76	-35.44
1976	3524.30	3923.59	399.29	3869.66	345.36
1977	1229.90	1968.42	738.52	1925.10	695.20
1978	2362.80	2119.89	-242.91	2129.79	-233.01
1979	2690.00	2640.39	-49.61	2641.52	-48.48
1980	2176.30	2704.87	528.57	2692.69	516.39
1981	2276.70	2336.21	59.51	2334.48	57.78
1982	3499.40	2828.63	-670.77	2846.21	-653.19
1983	2200.70	1555.53	-645.17	1618.07	-582.63
1984	2849.30	3166.85	317.55	3153.24	303.94

1985	2913.10	2687.49	-225.61	2692.69	-220.41
1986	2031.40	2655.72	624.32	2641.52	610.12
1987	1486.50	2359.79	873.29	2334.48	847.98
1988	1587.10	2050.11	463.01	2027.45	440.35
1989	2603.30	3852.30	1249.00	3716.14	1112.84
1990	2716.60	2955.78	239.18	2948.55	231.95
1991	2565.20	2220.37	-344.83	2232.14	-333.06
1992	1391.70	1750.02	358.32	1720.41	328.71
1993	2228.50	2651.13	422.63	2641.52	413.02
1994	1386.20	2262.01	875.81	2232.14	845.94
1995	1734.50	1719.14	-15.36	1720.41	-14.09
1996	3098.90	2787.32	-311.58	2795.04	-303.86
1997	4683.60	2894.47	-1789.13	2948.55	-1735.05
1998	2035.00	1806.81	-228.19	1822.76	-212.24
1999	3109.90	3263.49	153.59	3255.59	145.69
2000	2731.10	2587.06	-144.04	2590.34	-140.76
2001	1494.70	3227.49	1732.79	3153.24	1658.54
2002	3608.00	2722.87	-885.13	2743.86	-864.14
2003	2137.20	2288.04	150.84	2283.31	146.11
2004	2380.70	2595.24	214.54	2590.34	209.64

PCREG run on 25-Jul-05 at 10:37
JACKKNIFE REGRESSION PROGRAM

Input data from file: PCREG_temp.txt

VARIABLES:

Y1	Dwr_AprJul	Dworshak Apr-Jul Runoff in KAF
X1	SOI_SepSeptember	SOI
X2	HQSNovPpt	Nov Precip

REGRESSION EQUATION:

var	coef
X1	344.404
X2	182.715
C	1734.550

#obs=	44
#pc =	1
jr =	0.675
jse =	670.283
r =	0.711
se =	637.605

YEAR	OBSERVED	JCK REG COMPUTED	JCK REG ERROR	STD REG COMPUTED	STD REG ERROR
1961	2900.00	3562.13	662.13	3512.27	612.27
1962	3035.60	2730.23	-305.37	2737.38	-298.22
1963	1804.30	2817.83	1013.53	2792.92	988.62
1964	3406.20	2458.63	-947.57	2481.95	-924.25
1965	3310.00	3085.92	-224.08	3088.27	-221.73
1966	2149.80	1909.48	-240.32	1925.05	-224.75
1967	2693.30	2582.43	-110.87	2585.00	-108.30
1968	1975.40	2467.79	492.39	2458.28	482.88
1969	2878.70	2615.55	-263.15	2621.54	-257.16
1970	2622.60	1400.65	-1221.95	1518.60	-1104.00
1971	4050.80	3239.04	-811.76	3274.91	-775.89
1972	4688.90	3157.17	-1531.73	3215.62	-1473.28
1973	1262.40	1544.24	281.84	1517.87	255.47
1974	4759.90	4047.19	-712.71	4144.36	-615.54
1975	3342.20	3063.29	-278.91	3068.44	-273.76
1976	3524.30	3347.26	-177.04	3326.70	-197.60
1977	1229.90	1600.54	370.64	1568.48	338.58
1978	2362.80	2472.73	109.93	2471.82	109.02
1979	2690.00	2561.10	-128.90	2564.08	-125.92
1980	2176.30	2279.21	102.91	2278.77	102.47
1981	2276.70	2265.72	-10.98	2266.08	-10.62
1982	3499.40	2733.24	-766.16	2751.17	-748.23

1983	2200.70	1581.83	-618.87	1637.74	-562.96
1984	2849.30	3455.84	606.54	3420.08	570.78
1985	2913.10	2826.67	-86.43	2828.74	-84.36
1986	2031.40	2492.75	461.35	2481.85	450.45
1987	1486.50	2105.82	619.32	2081.53	595.03
1988	1587.10	1648.66	61.56	1644.67	57.57
1989	2603.30	3715.88	1112.58	3616.21	1012.91
1990	2716.60	2586.52	-130.08	2589.83	-126.77
1991	2565.20	2501.79	-63.41	2504.16	-61.04
1992	1391.70	2154.60	762.90	2137.83	746.13
1993	2228.50	2721.66	493.16	2710.25	481.75
1994	1386.20	1910.48	524.28	1882.93	496.73
1995	1734.50	2550.02	815.52	2536.14	801.64
1996	3098.90	3489.21	390.31	3453.07	354.17
1997	4683.60	3174.04	-1509.56	3240.30	-1443.30
1998	2035.00	1821.77	-213.23	1837.62	-197.38
1999	3109.90	3875.80	765.90	3794.10	684.20
2000	2731.10	2800.24	69.14	2798.23	67.13
2001	1494.70	2657.24	1162.54	2630.75	1136.05
2002	3608.00	2647.60	-960.40	2669.50	-938.50
2003	2137.20	2040.97	-96.23	2045.27	-91.93
2004	2380.70	2918.07	537.37	2902.37	521.67

```
PCREG run on 28-Sep-05 at 11:13
JACKKNIFE REGRESSION PROGRAM

Input data from file:  PCREG_temp.txt


VARIABLES:

  Y1    Dwr_AprJul  Dworshak Apr-Jul Runoff in KAF

  X1    SOI_SepSeptember SOI
  X2    HQSNovPpt   Nov Precip
  X5    HQSDecPpt   Dec Precip
  X10     PierceJan Jan Snow
  X12     HoodooJan Jan Snow
  X14     ElkButteJan    Jan Snow
  X15     HemlockJanJan Snow


REGRESSION EQUATION:

  var        coef
 ----        ----
  X1       271.684
  X2        99.827
  X5        45.827
  X10       35.139
  X12       13.611
  X14        9.769
  X15       12.046
    C     1095.649

#obs=           44
#pc =            2
 jr =        0.783
jse =      571.095
  r =        0.814
 se =      532.997

                      JCK REG    JCK REG    STD REG    STD REG
 YEAR     OBSERVED   COMPUTED      ERROR   COMPUTED      ERROR

 1961      2900.00    3053.72     153.72    3081.05     181.05
 1962      3035.60    3148.21     112.61    3132.06      96.46
 1963      1804.30    2317.98     513.68    2284.92     480.62
 1964      3406.20    2364.29   -1041.91    2386.43   -1019.77
 1965      3310.00    3651.40     341.40    3637.12     327.12
 1966      2149.80    1749.27    -400.53    1752.15    -397.65
 1967      2693.30    2482.63    -210.67    2488.55    -204.75
 1968      1975.40    2622.57     647.17    2615.18     639.78
 1969      2878.70    3072.01     193.31    3048.42     169.72
 1970      2622.60    1535.09   -1087.51    1594.83   -1027.77
 1971      4050.80    3253.78    -797.02    3292.31    -758.49
 1972      4688.90    3820.21    -868.69    3900.60    -788.30
```

1973	1262.40	1908.30	645.90	1826.84	564.44
1974	4759.90	4113.29	-646.61	4190.25	-569.65
1975	3342.20	2893.83	-448.37	2925.38	-416.82
1976	3524.30	3598.28	73.98	3596.94	72.64
1977	1229.90	1221.60	-8.30	1221.95	-7.95
1978	2362.80	3003.99	641.19	2928.82	566.02
1979	2690.00	2599.39	-90.61	2599.44	-90.56
1980	2176.30	2232.15	55.85	2237.43	61.13
1981	2276.70	1913.02	-363.68	1938.22	-338.48
1982	3499.40	2845.18	-654.22	2862.88	-636.52
1983	2200.70	1838.33	-362.37	1880.87	-319.83
1984	2849.30	3090.47	241.17	3087.21	237.91
1985	2913.10	3351.52	438.42	3288.44	375.34
1986	2031.40	2103.65	72.25	2116.84	85.44
1987	1486.50	1902.96	416.46	1882.05	395.55
1988	1587.10	1439.58	-147.52	1451.97	-135.13
1989	2603.30	3195.16	591.86	3194.89	591.59
1990	2716.60	2028.47	-688.13	2100.43	-616.17
1991	2565.20	2598.20	33.00	2563.54	-1.66
1992	1391.70	2291.66	899.96	2205.53	813.83
1993	2228.50	2703.65	475.15	2692.85	464.35
1994	1386.20	1749.44	363.24	1729.26	343.06
1995	1734.50	2773.21	1038.71	2646.96	912.46
1996	3098.90	2660.91	-437.99	2835.97	-262.93
1997	4683.60	4091.67	-591.93	4166.25	-517.35
1998	2035.00	1704.48	-330.52	1727.45	-307.55
1999	3109.90	3806.99	697.09	3765.89	655.99
2000	2731.10	2798.43	67.33	2797.57	66.47
2001	1494.70	2404.77	910.07	2400.87	906.17
2002	3608.00	2788.18	-819.82	2808.32	-799.68
2003	2137.20	1859.12	-278.08	1872.22	-264.98
2004	2380.70	2869.06	488.36	2855.55	474.85

```
PCREG run on 28-Sep-05 at 10:46
JACKKNIFE REGRESSION PROGRAM

Input data from file:  PCREG_temp.txt


VARIABLES:

  Y1    Dwr_AprJul  Dworshak Apr-Jul Runoff in KAF

  X1    SOI_SepSeptember SOI
  X17     PierceFeb Feb Snow
  X19     HoodooFeb Feb Snow
  X21     ElkButteFeb    Feb Snow
  X22     HemlockFebFeb Snow
  X48     DWR_Jan   Jan Flow


REGRESSION EQUATION:

  var        coef
 ----        ----
  X1      108.047
  X17      48.512
  X19      19.132
  X21      19.568
  X22      17.270
  X48       0.895
    C     413.051

#obs=          44
#pc =           1
 jr =       0.883
jse =     425.666
  r =       0.893
 se =     407.637

                    JCK REG    JCK REG    STD REG    STD REG
 YEAR    OBSERVED  COMPUTED      ERROR  COMPUTED      ERROR

 1961     2900.00   2355.54   -544.46   2370.14   -529.86
 1962     3035.60   3183.73    148.13   3179.19    143.59
 1963     1804.30   1794.17    -10.13   1792.49    -11.81
 1964     3406.20   2900.43   -505.77   2918.03   -488.17
 1965     3310.00   3873.01    563.01   3835.28    525.28
 1966     2149.80   2357.16    207.36   2354.29    204.49
 1967     2693.30   3102.45    409.15   3090.95    397.65
 1968     1975.40   2469.28    493.88   2457.09    481.69
 1969     2878.70   3562.33    683.63   3529.99    651.29
 1970     2622.60   2318.74   -303.86   2327.76   -294.84
 1971     4050.80   3956.80    -94.00   3963.27    -87.53
 1972     4688.90   4233.91   -454.99   4297.01   -391.89
 1973     1262.40   2075.34    812.94   2050.40    788.00
 1974     4759.90   4590.64   -169.26   4627.83   -132.07
```

1975	3342.20	3134.11	-208.09	3140.30	-201.90
1976	3524.30	3655.35	131.05	3645.02	120.72
1977	1229.90	965.37	-264.53	996.87	-233.03
1978	2362.80	2902.04	539.24	2891.60	528.80
1979	2690.00	2159.62	-530.38	2173.36	-516.64
1980	2176.30	2188.31	12.01	2188.22	11.92
1981	2276.70	1339.33	-937.37	1397.80	-878.90
1982	3499.40	3096.88	-402.52	3110.62	-388.78
1983	2200.70	1941.44	-259.26	1955.85	-244.85
1984	2849.30	2437.91	-411.39	2444.77	-404.53
1985	2913.10	2786.15	-126.95	2795.83	-117.27
1986	2031.40	2065.23	33.83	2064.19	32.79
1987	1486.50	1832.85	346.35	1815.79	329.29
1988	1587.10	1647.26	60.16	1642.24	55.14
1989	2603.30	3001.41	398.11	2982.16	378.86
1990	2716.60	2396.52	-320.08	2404.15	-312.45
1991	2565.20	2630.58	65.38	2629.47	64.27
1992	1391.70	2162.65	770.95	2143.19	751.49
1993	2228.50	2357.94	129.44	2356.30	127.80
1994	1386.20	1667.60	281.40	1652.10	265.90
1995	1734.50	2453.41	718.91	2446.43	711.93
1996	3098.90	2682.38	-416.52	2678.79	-420.11
1997	4683.60	4048.63	-634.97	4112.16	-571.44
1998	2035.00	1943.66	-91.34	1948.05	-86.95
1999	3109.90	3275.77	165.87	3270.10	160.20
2000	2731.10	2675.47	-55.63	2676.42	-54.68
2001	1494.70	1791.51	296.81	1770.05	275.35
2002	3608.00	3045.27	-562.73	3060.48	-547.52
2003	2137.20	1784.89	-352.31	1801.92	-335.28
2004	2380.70	2629.50	248.80	2624.78	244.08

```
PCREG run on 21-Jul-05 at 15:06
JACKKNIFE REGRESSION PROGRAM

Input data from file:  PCREG_temp.txt


VARIABLES:

  Y1    Dwr_AprJul  Dworshak Apr-Jul Runoff in KAF

  X1    SOI_SepSeptember SOI
  X24     PierceMar Mar Snow
  X25     LostLkMar Mar Snow
  X26     HoodooMar Mar Snow
  X28     ElkButteMar    Mar Snow
  X29     HemlockMarMar Snow
  X48     DWR_Jan   Jan Flow
  X49     DWR_Feb   Feb Flow


REGRESSION EQUATION:

  var        coef
 ----        ----
  X1       90.466
  X24      30.913
  X25       9.997
  X26      13.194
  X28      12.426
  X29      13.024
  X48       0.800
  X49       0.125
    C     169.000

#obs=          44
#pc =           1
 jr =       0.906
jse =     383.329
  r =       0.915
 se =     366.517

                    JCK REG   JCK REG   STD REG   STD REG
 YEAR    OBSERVED  COMPUTED     ERROR  COMPUTED     ERROR

 1961     2900.00   2636.22   -263.78   2642.02   -257.98
 1962     3035.60   2861.94   -173.66   2866.64   -168.96
 1963     1804.30   1809.11      4.81   1806.26      1.96
 1964     3406.20   2789.72   -616.48   2809.98   -596.22
 1965     3310.00   3771.01    461.01   3744.58    434.58
 1966     2149.80   2319.55    169.75   2316.23    166.43
 1967     2693.30   3242.61    549.31   3223.55    530.25
 1968     1975.40   2340.30    364.90   2328.48    353.08
 1969     2878.70   3515.20    636.50   3484.35    605.65
 1970     2622.60   2525.20    -97.40   2531.75    -90.85
```

1971	4050.80	3530.69	-520.11	3560.95	-489.85
1972	4688.90	4761.53	72.63	4752.41	63.51
1973	1262.40	1953.89	691.49	1924.05	661.65
1974	4759.90	4934.00	174.10	4899.85	139.95
1975	3342.20	3180.82	-161.38	3188.66	-153.54
1976	3524.30	3592.78	68.48	3585.08	60.78
1977	1229.90	1057.36	-172.54	1069.07	-160.83
1978	2362.80	2727.78	364.98	2721.37	358.57
1979	2690.00	2528.31	-161.69	2532.91	-157.09
1980	2176.30	1981.37	-194.93	1987.83	-188.47
1981	2276.70	1634.14	-642.56	1657.50	-619.20
1982	3499.40	3124.27	-375.13	3142.99	-356.41
1983	2200.70	2281.05	80.35	2288.12	87.42
1984	2849.30	2338.51	-510.79	2348.48	-500.82
1985	2913.10	2749.85	-163.25	2760.61	-152.49
1986	2031.40	2306.33	274.93	2295.81	264.41
1987	1486.50	1839.26	352.76	1820.52	334.02
1988	1587.10	1671.27	84.17	1661.80	74.70
1989	2603.30	2732.88	129.58	2712.35	109.05
1990	2716.60	2701.33	-15.27	2701.52	-15.08
1991	2565.20	2567.80	2.60	2566.36	1.16
1992	1391.70	2007.46	615.76	1988.29	596.59
1993	2228.50	2027.22	-201.28	2031.59	-196.91
1994	1386.20	1785.42	399.22	1762.23	376.03
1995	1734.50	2207.60	473.10	2180.13	445.63
1996	3098.90	2836.59	-262.31	2800.78	-298.12
1997	4683.60	3942.87	-740.73	4007.38	-676.22
1998	2035.00	1820.64	-214.36	1830.13	-204.87
1999	3109.90	3726.57	616.67	3688.42	578.52
2000	2731.10	2675.81	-55.29	2676.94	-54.16
2001	1494.70	1628.72	134.02	1607.71	113.01
2002	3608.00	2909.73	-698.27	2928.54	-679.46
2003	2137.20	1774.36	-362.84	1784.49	-352.71
2004	2380.70	2394.06	13.36	2393.96	13.26

PCREG run on 21-Jul-05 at 15:07
JACKKNIFE REGRESSION PROGRAM

Input data from file: PCREG_temp.txt

VARIABLES:

Y1	Dwr_AprJul	Dworshak Apr-Jul Runoff in KAF
X1	SOI_Sep	September SOI
X31	PierceApr	Apr Snow
X32	LostLkApr	Apr Snow
X33	HoodooApr	Apr Snow
X35	ElkButteApr	Apr Snow
X36	HemlockApr	Apr Snow
X48	DWR_Jan	Jan Flow
X49	DWR_Feb	Feb Flow
X50	DWR_Mar	Mar Flow

REGRESSION EQUATION:

var	coef
X1	95.929
X31	26.078
X32	9.215
X33	12.456
X35	12.913
X36	13.201
X48	0.745
X49	0.120
X50	0.321
C	-179.797

#obs=	44
#pc =	1
jr =	0.939
jse =	312.163
r =	0.945
se =	297.534

YEAR	OBSERVED	JCK REG COMPUTED	JCK REG ERROR	STD REG COMPUTED	STD REG ERROR
1961	2900.00	2901.37	1.37	2905.26	5.26
1962	3035.60	3014.22	-21.38	3020.22	-15.38
1963	1804.30	2038.99	234.69	2028.20	223.90
1964	3406.20	3312.56	-93.64	3340.17	-66.03
1965	3310.00	3726.00	416.00	3705.41	395.41
1966	2149.80	2554.91	405.11	2546.51	396.71
1967	2693.30	3111.48	418.18	3101.36	408.06
1968	1975.40	2284.69	309.29	2274.02	298.62

1969	2878.70	3159.14	280.44	3149.37	270.67
1970	2622.60	2539.72	-82.88	2545.07	-77.53
1971	4050.80	3731.36	-319.44	3759.34	-291.46
1972	4688.90	4543.84	-145.06	4645.55	-43.35
1973	1262.40	1866.60	604.20	1834.66	572.26
1974	4759.90	4697.41	-62.49	4713.30	-46.60
1975	3342.20	3349.04	6.84	3356.54	14.34
1976	3524.30	3597.20	72.90	3592.10	67.80
1977	1229.90	1387.35	157.45	1357.05	127.15
1978	2362.80	2279.06	-83.74	2280.44	-82.36
1979	2690.00	2360.80	-329.20	2369.87	-320.13
1980	2176.30	2193.92	17.62	2192.14	15.84
1981	2276.70	1634.02	-642.68	1654.63	-622.07
1982	3499.40	3263.80	-235.60	3284.81	-214.59
1983	2200.70	2216.68	15.98	2227.04	26.34
1984	2849.30	2501.36	-347.94	2507.16	-342.14
1985	2913.10	2660.96	-252.14	2674.58	-238.52
1986	2031.40	2342.06	310.66	2257.48	226.08
1987	1486.50	1794.97	308.47	1778.09	291.59
1988	1587.10	1737.98	150.88	1723.56	136.46
1989	2603.30	2935.72	332.42	2918.40	315.10
1990	2716.60	2479.68	-236.92	2484.11	-232.49
1991	2565.20	2595.04	29.84	2592.72	27.52
1992	1391.70	1601.02	209.32	1588.86	197.16
1993	2228.50	1878.66	-349.84	1888.63	-339.87
1994	1386.20	1515.32	129.12	1500.56	114.36
1995	1734.50	2148.66	414.16	2114.62	380.12
1996	3098.90	2643.23	-455.67	2584.28	-514.62
1997	4683.60	4315.19	-368.41	4361.39	-322.21
1998	2035.00	1526.85	-508.15	1556.58	-478.42
1999	3109.90	3736.32	626.42	3700.04	590.14
2000	2731.10	2602.83	-128.27	2605.58	-125.52
2001	1494.70	1408.99	-85.71	1392.33	-102.37
2002	3608.00	3177.30	-430.70	3194.16	-413.84
2003	2137.20	2237.40	100.20	2223.29	86.09
2004	2380.70	2073.80	-306.90	2083.20	-297.50

```
PCREG run on 21-Jul-05 at 15:27
JACKKNIFE REGRESSION PROGRAM

Input data from file:  PCREG_temp.txt


VARIABLES:

  Y2    Dwr_MayJul  Dworshak May-Jul Runoff in KAF

  X1    SOI_SepSeptember SOI
  X38     LostLkMay May Snow
  X39     HoodooMay May Snow
  X41     ElkButteMay    May Snow
  X42     HemlockMayMay Snow


REGRESSION EQUATION:

  var        coef
 ----        ----
  X1       103.446
  X38        9.197
  X39       11.712
  X41       12.892
  X42       11.591
    C     -149.911

#obs=           44
#pc =            1
 jr =        0.941
jse =      267.853
  r =        0.947
 se =      253.785

                      JCK REG    JCK REG    STD REG    STD REG
 YEAR     OBSERVED   COMPUTED      ERROR   COMPUTED      ERROR

 1961      2209.90    2592.62     382.72    2577.88     367.98
 1962      2009.30    2087.95      78.65    2086.11      76.81
 1963      1320.70    1662.40     341.70    1652.14     331.44
 1964      2876.40    2784.07     -92.33    2788.83     -87.57
 1965      2220.70    2624.80     404.10    2608.28     387.58
 1966      1449.40    1702.86     253.46    1700.23     250.83
 1967      2266.60    2450.14     183.54    2443.96     177.36
 1968      1559.60    2032.63     473.03    2021.45     461.85
 1969      1886.80    2155.09     268.29    2146.25     259.45
 1970      2262.90    2254.07      -8.83    2260.41      -2.49
 1971      3328.10    3072.19    -255.91    3092.30    -235.80
 1972      3931.70    3477.21    -454.49    3528.84    -402.86
 1973       967.20    1364.92     397.72    1350.64     383.44
 1974      3760.10    3441.30    -318.80    3475.70    -284.40
 1975      2924.40    2748.79    -175.61    2757.33    -167.07
 1976      2702.20    2792.87      90.67    2781.35      79.15
```

1977	856.50	579.23	-277.27	609.78	-246.72
1978	1708.70	1647.42	-61.28	1649.70	-59.00
1979	2089.10	2021.54	-67.56	2023.03	-66.07
1980	1540.80	1375.64	-165.16	1381.65	-159.15
1981	1746.40	1100.89	-645.51	1135.25	-611.15
1982	2858.50	2654.39	-204.11	2662.52	-195.98
1983	1749.30	1614.69	-134.61	1628.49	-120.81
1984	2234.70	1975.43	-259.27	1980.04	-254.66
1985	2056.70	2098.33	41.63	2097.33	40.63
1986	1306.60	1550.21	243.61	1543.06	236.46
1987	923.00	893.57	-29.43	900.28	-22.72
1988	983.10	1065.95	82.85	1061.09	77.99
1989	1669.70	2045.17	375.47	2014.34	344.64
1990	1774.40	1743.49	-30.91	1742.93	-31.47
1991	1952.60	2153.41	200.81	2148.84	196.24
1992	884.40	1065.48	181.08	1054.75	170.35
1993	1647.80	1688.00	40.20	1687.65	39.85
1994	829.60	823.86	-5.74	825.83	-3.77
1995	1313.60	1520.35	206.75	1518.67	205.07
1996	2062.10	1989.82	-72.28	1989.99	-72.11
1997	3621.00	3545.19	-75.81	3550.81	-70.19
1998	1520.20	950.83	-569.37	985.53	-534.67
1999	2494.60	2736.77	242.17	2725.56	230.96
2000	1770.20	1662.99	-107.21	1666.11	-104.09
2001	1152.60	1182.45	29.85	1170.82	18.22
2002	2743.80	2504.98	-238.82	2512.72	-231.08
2003	1500.50	1510.86	10.36	1510.83	10.33
2004	1713.70	1314.17	-399.53	1330.91	-382.79

PCREG run on 21-Jul-05 at 15:40
JACKKNIFE REGRESSION PROGRAM

Input data from file: PCREG_temp.txt

VARIABLES:

Y3	Dwr_JunJul	Dworshak Jun-Jul Runoff in KAF
X43	LostLkJun	Jun Snow
X44	HoodooJun	Jun Snow
X46	ElkButteJun	Jun Snow
X47	HemlockJunJun	Snow

REGRESSION EQUATION:

var	coef
X43	5.703
X44	7.882
X46	8.347
X47	7.450
C	198.613

#obs=	38
#pc =	1
jr =	0.945
jse =	166.327
r =	0.952
se =	154.961

YEAR	OBSERVED	JCK REG COMPUTED	JCK REG ERROR	STD REG COMPUTED	STD REG ERROR
1967	1216.90	1496.99	280.09	1478.59	261.69
1968	797.30	810.52	13.22	811.36	14.06
1969	706.90	793.26	86.36	791.46	84.56
1970	1208.60	1068.37	-140.23	1070.51	-138.09
1971	1505.60	1509.72	4.12	1508.84	3.24
1972	1970.00	1942.70	-27.30	1945.92	-24.08
1973	408.00	482.41	74.41	480.00	72.00
1974	2435.20	1968.93	-466.27	2044.51	-390.69
1975	1782.70	1644.25	-138.45	1654.07	-128.63
1976	1132.50	877.33	-255.17	885.99	-246.51
1977	335.10	316.23	-18.87	320.04	-15.06
1978	877.60	996.41	118.81	995.67	118.07
1979	744.40	963.39	218.99	957.55	213.15
1980	706.60	817.78	111.18	816.20	109.60
1981	994.10	496.10	-498.00	520.36	-473.74
1982	1522.30	1392.31	-129.99	1398.14	-124.16
1983	907.10	975.15	68.05	973.34	66.24
1984	1242.40	1255.90	13.50	1254.88	12.48

1985	878.00	837.32	-40.68	838.49	-39.51
1986	505.60	585.81	80.21	582.60	77.00
1987	316.90	305.91	-10.99	307.45	-9.45
1988	431.70	552.44	120.74	547.17	115.47
1989	748.40	1048.89	300.49	1040.67	292.27
1990	990.90	1046.29	55.39	1044.76	53.86
1991	1018.60	1158.41	139.81	1153.73	135.13
1992	334.30	328.51	-5.79	329.85	-4.45
1993	581.10	496.84	-84.26	501.36	-79.74
1994	343.70	249.14	-94.56	259.31	-84.39
1995	634.70	682.14	47.44	680.58	45.88
1996	983.80	1177.40	193.60	1169.00	185.20
1997	1656.00	1729.17	73.17	1720.02	64.02
1998	568.40	452.95	-115.45	459.89	-108.51
1999	1475.10	1486.06	10.96	1484.91	9.81
2000	772.20	802.57	30.37	801.73	29.53
2001	440.60	323.51	-117.09	332.64	-107.96
2002	1538.40	1541.37	2.97	1539.92	1.52
2003	727.00	811.64	84.64	809.26	82.26
2004	774.10	699.38	-74.72	702.05	-72.05