Water Supply Forecasting

June 9, 1992 Technical Workshop

The California Cooperative Snow Surveys Program began over 60 years ago in 1929, when the State Legislature established a formal program to replace the sporadic and uncoordinated one that had existed since before World War I.

Each spring, about 50 agencies pool their efforts in collecting snow data at about 300 snow courses. The snowpack information is used to predict how much spring runoff to expect. The water forecasts are vital for planning and management of the State's water resources systems — to benefit all Californians.

Runoff forecasts are made systematically, based on historical regression relationships between the volume of April through July runoff and the snow water content, precipitation , and runoff in preceding months. These are the primary hydrologic variables and we will spend today describing how these variables are measured or calculated and how the data are used in forecasting.

How Snow Course Measurements Are Made

Snowpack water equivalent measurements are made at about 310 locations throughout California. These data collection sites are called snow courses. A snow course is simply a transect along which snow depth and water equivalent observations are made at a fixed number of points, usually at a regular interval. Courses generally consist of between 7-10 sample points. A typical snowcourse map is attached. Courses are located through out the State from the Santa Ana River in the South to Surprise Valley in the North. Courses range in elevation from 4350 feet in the Mokelumne River Basin to 11,450 feet in the San Joaquin River Basin.

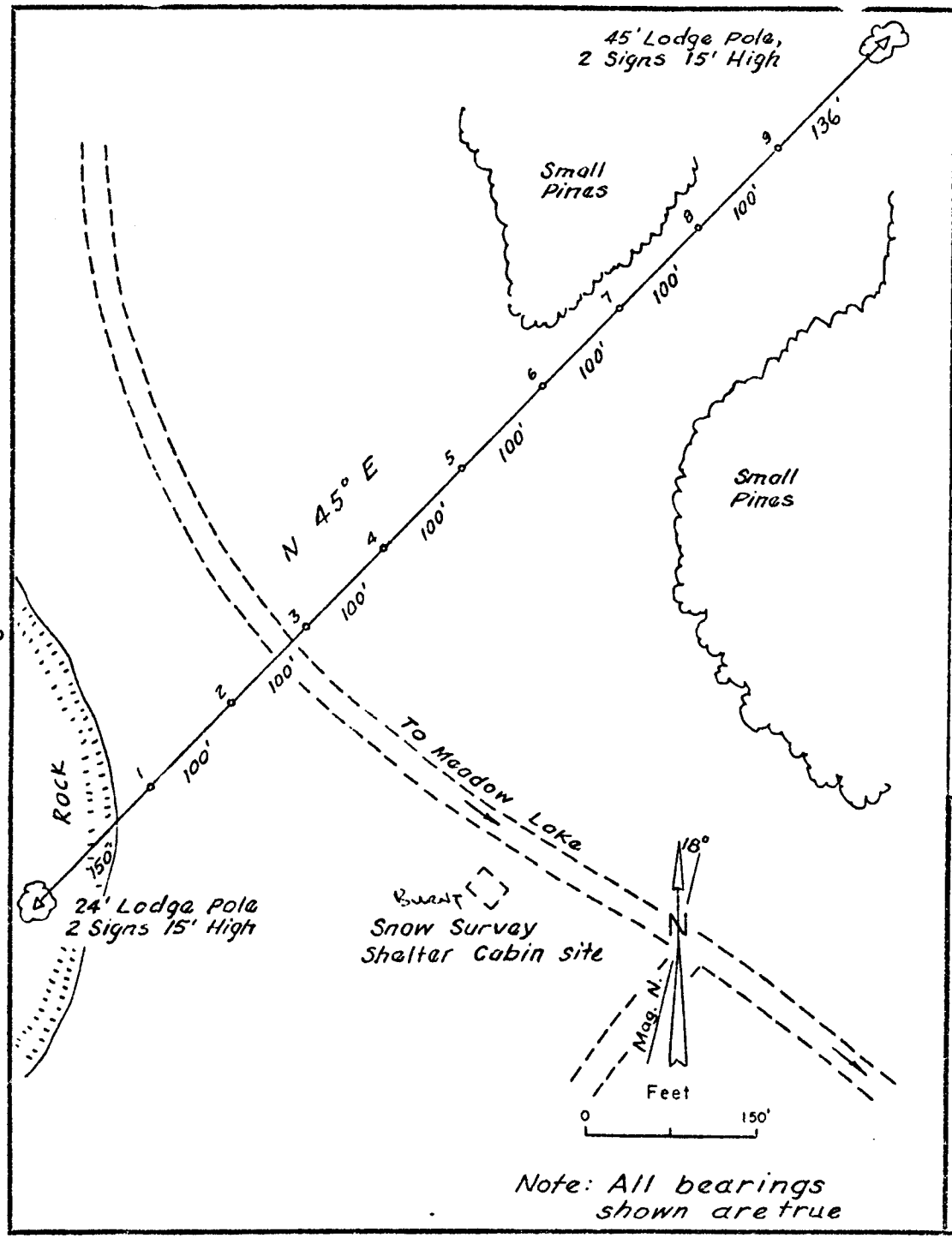
Courses are distributed within a drainage basin to reflect the differing pattern of snow accumulation. Locations are intended to reflect the vegetation, geographical and elevation variations for a particular basin.

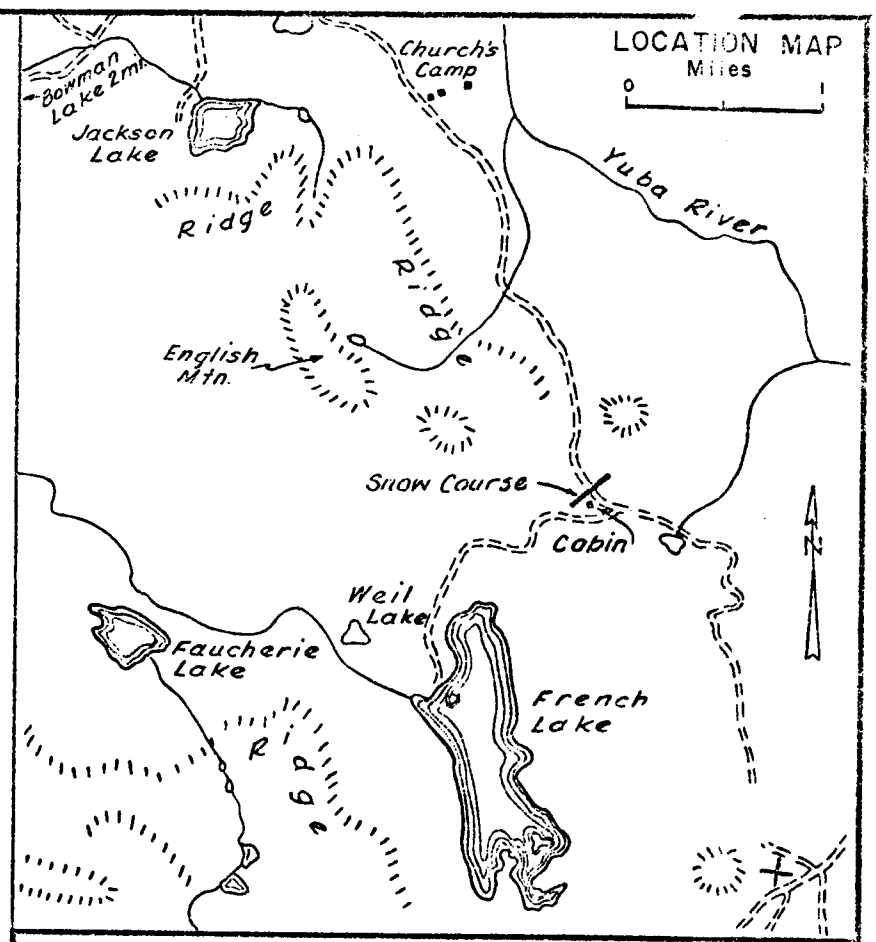
Observations are made by first measuring from an endpoint marker, usually a tree or 2 inch galvanized pipe sunk in the ground with a standard snow course marker affixed to it. The surveyors measure off the distance from the endpoint to the first point according to the map and make their first observation. The surveyors keep themselves on the course by lining up between the end points.

The actual measurements of snow water equivalent are made gravimetrically. A tube, approximately 1.5 inches in diameter, with graduated markings on the outside is pushed vertically into the snow to extract a core sample of snow from the surface to the ground. Tube sections are 30 inches in length and threaded and a sample set consists of 4 to 6 sections such that an appropriate number of tubes can be assembled to penetrate the entire pack. The core sample is then weighed inside the tube using a scale. The core sample is discarded and the weight of the empty tube recorded. The difference between the weight of the tube with the core and without the core is the weight of the snow itself. Since snow is frozen water and air, the weight of the snow is the weight of the water. The diameter of the snowtube has been determined so that one ounce of water is equivalent to one inch of water.

This procedure is repeated at each point on the course. When all points have been sampled, the depth and water content values are summed and averaged. Each snow course will have one average depth and water content value for the date of measurement. The density is determined by the water content divided by the depth and assists in quality control.

The Department puts forth a considerable effort in standardizing snow course data collection. DWR conducts training in the field with cooperating agencies and checks the arithmetic on nearly 1000 snow notes each year.





STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING
CALIFORNIA COOPERATIVE SNOW SURVEYS

SNOW COURSE MAP

ENGLISH MOUNTAIN # 68

DRAINAGE: YUBA RIVER
ELEVATION: 7,100'

CORRECTED 1962, 1973
REVISED 1958
REVISED 1953
COURSE ESTABLISHED 1927

G-184

DR. W. M. H. 1959

87861 12-58 800 STO

FORM 130 STATE OF CALIFORNIA 68

DEPARTMENT OF WATER RESOURCES

DIVISION OF RESOURCES PLANNING
SACRAMENTO

CALIFORNIA COOPERATIVE SNOW SURVEYS

SNOW SURVEY NOTES

Drainage Basin S. Yuba

Snow Course English Mt. #68

Party Fakenburg, Lynch, Freeman

Date Feb 25, 1986

*Description or Number of Course	†Sample Number	Depth of Snow Inches	Length of Core Inches	Weight of Empty Tube	Weight of Tube and Core	Water Content Inches	Density Percent	Remarks (See reverse)
150	1	102	90	66.0	120.0	54.0		52.9
100	2	100	90	66	118.5	52.5		52.5
	3	101	90	66	122	56.0		55.4
	4	103	91	66	119	53.0		51.4
	5	111	100	66	123.5	57.5		51.8
	6	111	103	66	127.5	61.5		55.4
	7	101	80	66	114.0	48.0		47.5
	8	102	90	66	115.0	49.0		48.0
100	9	119	112	66	124	58.0		48.7
		950				489.5		
		105.6				54.38		51.5
						54.4		

*Show number or description as given on sketch map, *i. e.*, "Course No. 1," or "Major Course," or "N 5° E," etc.

†Always start measurements for sampling from the *initial* point as shown by the sketch map of the course and follow the spacing for samples as indicated. Particular care should be taken to note any *irregular* spacing between samples.

No. 1 of 1 sheets. Comp. by Lynch Checked by ✓

NOTE.—Please fill in while in the field.

DATE OF SURVEY: Began 1200 a. m. p. m. Ended 1240 a. m. p. m.

SAMPLING CONDITIONS

(Please check items descriptive of present conditions.)

Weather at Time of Sampling

	Clear.		Snowing.
✓	Partly cloudy.		Blowing.
	Overcast.		Freezing.
	Raining.		Thawing.

Snow Conditions at Snow Course

- ✓ Snow samples obtained easily.
- Snow samples obtained with moderate difficulty.*
- Snow samples obtained with extreme difficulty.*
- Ice layer on ground. How thick? ..... inches.
- Ground frozen under snow.
- Ground not frozen under snow.
- Ground dry under snow.
- Ground damp under snow.
- ✓ Ground wet (saturated) under snow.

General Snow Conditions

1. What elevation is snow line generally? 5500 ft.
2. Is snow melting on north and east slopes? no
3. Is snow melting on south and west slopes? yes
4. How many inches of new snow at snow course? — in.
5. Is there evidence of snowslides? yes snow Rollers.

General Stream-Flow Conditions

1. Are very small streams running? Yes ✓ No
2. Are small streams bridged over by snow? Yes No ✓
3. Are streams clear or muddy? (*Check one*) Clear ✓ Muddy

*Explain fully under remarks.

REMARKS:

PH 2 = 5.0

PH 9 = 5.0

65454 11-57 1M △ SPO

4

DEPARTMENT OF WATER RESOURCES
CALIFORNIA DATA EXCHANGE CENTER

SNOW COURSE # 68 -- ENGLISH MOUNTAIN YUBA R

3-LETTER ID: ENM
ELEVATION: 7100 FEET
NO. OF SAMPLE POINTS: 8
AVG APRIL 1 WATER CONTENT: 45.7"

LATITUDE: 39D 26' 10"
LONGITUDE: 120D 31' 30"
RECORD BEGAN: 1927
ASPECT:

MEAN DEPTHS AND WATER CONTENTS ARE IN INCHES

YEAR	JANUARY			FEBRUARY			MARCH			APRIL			MAY			JUNE/SUPPLEMENT		
	DATE	DEPTH	WC	DATE	DEPTH	WC	DATE	DEPTH	WC	DATE	DEPTH	WC	DATE	DEPTH	WC	DATE	DEPTH	WC
1927										3-27	101.4	50.8						
1928										4- 1	75.0	26.0						
1929										4- 1	57.0	23.8						
1930										4- 4	68.4	33.6						
1931										4- 1	52.1	22.3						
1932										4- 1	99.6	52.3						
1933										4- 5	80.8	39.2						
1934										4- 3	33.1	17.5						
1935										4- 3	109.7	44.0						
1936										4- 7	146.7	67.0						
1937										4- 1	119.4	50.5						
1938										4- 4	169.4	74.0						
1939										3-27	77.6	30.7						
1940										4- 2	107.9	44.7						
1941										4- 6	112.2	52.7						
1942										3-26	97.3	45.4						
1943										3-25	102.7	50.6						
1944										3-28	85.8	38.8						
1945										3-23	104.1	38.9						
1946										3-26	101.7	49.3						
1947										3-28	69.2	28.8						
1948										3-31	77.6	25.4						
1949										3-31	114.8	44.1						
1950																		
1951																		
1952																		
1953										4- 3	76.9	36.7						
1954										4- 2	86.3	37.1						
1955										4- 1	79.2	31.8						
1956										3-28	124.9	64.7						
1957										4- 2	94.0	47.1						
1958													4-23	147.0	75.9			
1959										4- 1	65.6	26.8						
1960										3-29	77.7	38.9						
1961							3- 3	52.4	21.4	3-30	77.8	30.1						
1962							3- 8	144.8	50.0	3-30	131.3	59.0						
1963							2-28	.0	.0	4- 4	45.4	13.4						
1964							3- 3	80.7	31.0	3-27	91.9	35.3						
1965							3- 2	105.5	51.9	3-28	120.8	54.8						
1966							3- 3	108.9	38.5	3-29	87.8	41.0						
1967							3- 1	102.4	44.2	3-25	123.2	56.4	5- 1	164.6	72.4	6- 8	91.4	48.9

1968							3- 4	64.8	30.9	3-25	81.2	35.6						
1969										3-27	163.3	83.8						
1970							2-24	73.1	32.1	4- 2	68.6	32.4						
1971							3- 6	119.2	53.9	4- 5	131.8	62.1						
1972							3- 1	100.3	42.7	3-31	71.3	37.2	4-19	78.7	39.4			
1973							3- 3	126.7	45.8	3-29	121.7	51.6	4-26	93.7	46.9			
1974							3- 3	113.9	41.9	3-21	101.4	48.7						
1975							2-27	107.8	40.7	3-29	147.7	59.6						
1976							2-26	50.4	12.4	3-25	54.3	21.1						
1977							2-24	35.0	11.0	3-29	40.1	16.7						
1978	1- 7	92.5	31.8	1-24	122.8	48.0	2-22	135.7	58.0	3-24	140.2	65.4	4-28	133.4	69.7	5-25	89.2	46.6
1979	1- 2	32.5	8.4	1-26	54.7	16.8	2-27	103.3	33.6	3-29	104.0	41.0	4-24	92.4	41.6			
1980	12-31	18.0	7.4	1-24	61.3	30.9	2-26	117.4	48.8	3-25	126.3	65.2	4-28	97.2	51.6			
1981				1-31	75.1	21.4	2-26	69.4	24.9	3-28	82.8	33.6	4-29	47.0	22.1			
1982	1- 9	76.2	23.3	1-27	89.6	30.1	2-24	53.2	29.7	4- 7	155.3	59.1	4-28	104.5	54.6			
1983	1- 4	89.2	35.2	1-31	155.6	47.0	2-23	153.6	65.1	3-31	192.6	94.2	4-25	195.1	95.7	5-25	156.6	94.9
1984	1- 3	71.3	34.4	1-31	67.7	32.0	2-29	100.0	45.0	3-28	93.0	46.8	4-24	90.9	49.1			
1985	1- 2	57.7	21.9	1-29	63.0	22.8	2-25	70.7	29.6	3-29	110.7	43.4	5- 1	43.7	23.6	5-21	.0	.0
1986	1- 2	53.0	21.4	1-28	59.1	25.9	2-25	105.6	54.4	3-25	107.7	55.0	5- 1	63.6	38.3			
1987	1- 2	23.1	5.4	1-29	50.4	12.9	2-26	61.8	23.2	3-26	76.7	31.7	4-28	17.9	9.2			
1988	1- 6	65.3	19.0	1-27	68.7	25.7	2-26	57.6	26.1	3-29	42.1	20.4	4-27	24.3	10.1			
1989	1- 3	72.8	24.8	1-27	77.8	29.6	2-27	84.2	35.4	3-27	106.5	49.3	4-28	59.8	31.0	6- 1	.0	.0
1990	1- 3	32.2	8.1	1-29	44.0	14.6	2-27	66.5	24.0	3-29	60.6	27.2	4-26	22.6	11.0			
1991				1-29	19.6	5.6	3- 6	51.4	19.1	3-29	98.3	34.6	4-26	77.1	31.7	5-29	17.8	8.6
1992	12-22	24.6	7.3	1-29	39.0	13.2	2-27	69.5	26.1	3-26	65.0	29.0	4-28	12.1	6.0			

UNIMPAIRED RUNOFF

Since the relationships of runoff to precipitation, snow, and other hydrologic variables are natural, we prefer to work with natural or unimpaired runoff. These are the amounts of water produced in a stream unaltered by upstream diversions, storage, or by export or import of water to or from other basins. To get unimpaired runoff, measured flow amounts have to be adjusted to take out the effect of man-made works, such as reservoir, diversions, or imports. All forecasts, whether for the April through July snowmelt runoff period or for the entire water year, October through September, are for unimpaired runoff.

The attached chart shows, in a simplified manner, the calculation of unimpaired runoff at Station A. To do so, we need the measured flow at the station, then adjust for the following items:

1. Reservoir storage change (▲ S)

2. Reservoir evaporation, if significant (E)

3. Add exports to other basins or which bypass the measuring station. (Ex)

4. Subtract imports from outside the river basin (I)

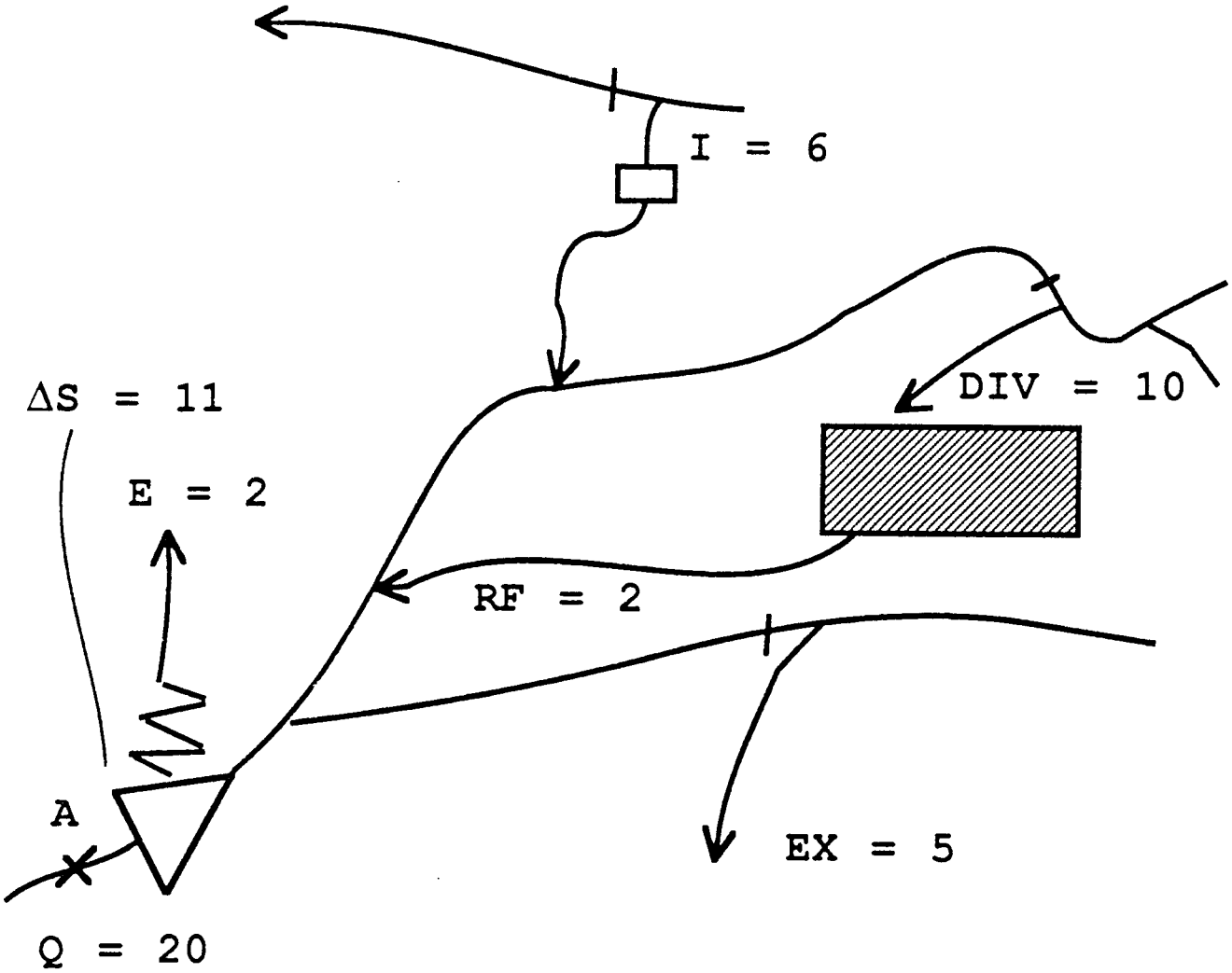
5. Add diversions of water to irrigated or urban lands within the basin (DIV)

6. Subtract return flow from these same irrigated lands (RF)

Often, items 5 and 6 are combined into a single-term, depletion, which represents the consumption of water on developed lands within a basin. In many of our mountain basins, development is not significant and the term can be ignored.

The tabulation provides a sample of the calculation of unimpaired runoff for the Yuba River at Smartville for the month of February during two recent years. Note that there are many reservoirs and diversions to consider.

An initial calculation of unimpaired runoff is made during the current year using preliminary data from a large number of sources. Eventually, as records are checked and published a final determination of monthly unimpaired flow is made, which may differ slightly from the earlier values. Accurate estimates of unimpaired runoff are absolutely essential to forecasting.



$$Q_{RO} = Q_A + Ex - I + \Delta S + E + DIV - RF$$

$$= 20 + 5 - 6 + 11 + 2 + 10 - 2$$

$$= 40$$

UNIMPAIRED RUNOFF

UNIMPAIRED STREAMFLOW COMPUTATION
YUBA RIVER NEAR SMARTVILLE
1000 Acre-Feet

Description			Feb. 86		Feb 92
Accumulative Measured Flow = (1+2)					
(1) Measured at Station (#11418000)		Q_A	880.2	Q_A	78.7
(2) Deer Creek near Smartville (USGS #11418500)		Q_A	77.2	Q_A	17.2
Exports		EX		EX	
Drum Canal	(PG&E)		28.3		21.3
DS Canal	(NID)		0.3		0.3
Cascade Ditch	(NID)		1.4		1.5
South Yuba Canal	(PG&E) [YB-31]		3.2		2.1
Slate Creek Tunnel	(PG&E)		24.9		14.1
Imports		I		I	
South Yuba Canal	(PG&E) [YB-34]		-2.4		-2.0
Change in Storage		▲S	338.1	▲S	109.3
Evaporation		E		E	
Irrigation & Consumptive Use		DIV		DIV	
Total		Q_{RO}	1351.2	Q_{RO}	242.5
Accum Total			1828.1		363.1
Monthly Normal			298.5		298.5
Accum. Normal			979.6		979.6

RESERVOIRS

	Jan. 86	Feb. 86	Jan. 92	Feb. 92
Lake Spaulding System (PG&E)	40.8	101.5	29.1	36.2
Narrows Res. (USBR)	56.5	72.9	60.0	63.6
Bowman Lake (NID)	34.6	65.0	24.9	25.3
Bullards Bar Res. (USBR)	622.0	818.5	465.1	555.1
Scotts Flat Res. (NID	39.0	48.5	33.7	39.9
French Lake (NID)	4.2	6.1	8.0	8.4
Jackson Meadows Res. (NID)	32.6	55.3	34.6	36.2
Total Storage	829.7	1167.8	655.4	764.7

A SUMMARY OF CALIFORNIA COOPERATIVE SNOW SURVEYS WATER SUPPLY FORECASTING PROCEDURES

The water supply forecasting procedures are based on multiple linear regression equations which relate snow, precipitation, and runoff terms to April-July unimpaired runoff.[1] Forecasts are made monthly from February 1 through May 1 each year and published in Bulletin 120, Water Conditions in California. Forecast updates on major Central Valley rivers are produced generally on a weekly basis until mid-June or later for heavy snowmelt years.

A single equation is used during the February to June forecast season, rather than using a different forecast equation for each date of forecast. The equations are developed for April 1 conditions, which is typically the date of maximum accumulation of snow water content and therefore has the highest correlation with April-July runoff.

Forecasts prior to April 1 use hydrologic conditions as of the date of forecast plus the historic median accumulation of precipitation and snow from the date of forecast to April 1. Forecasts after April 1 use the April 1 snow index term and actual spring precipitation as it occurs with assumed median precipitation after the date of forecast.

BASIC EQUATION

The general form of a water supply forecast equation is:

$$AJRO = C1(HSNOW) + C2(LSNOW) + C3(OMPT) + C4(AJPT) + C5(OMRO) + C6(PYRO) + K$$

where,

AJRO is April-July runoff in thousand acre-feet
HSNO is the high elevation April 1 snow index
LSNO is the low elevation April 1 snow index
OMPT is the October-March precipitation index
AJPT is the April-June precipitation index
OMRO is the October-March runoff
PYRO is the prior year April-July runoff
K is a constant
C1 through C6 are fixed coefficients.

Many of the forecast equations use combinations of power terms to represent the nonlinear relationship between the variables. Snow and precipitation terms are indexes of normal snowpack

[1]Unimpaired runoff is the computed flow representing the natural production of the watershed, unaltered by upstream diversions, storage, or by export or import of water to or from other watersheds.

water content and precipitation. Indexes reduce the effect of missing data, a common operational problem.

SNOW INDEXES

The snow index terms HSNO and LSNO use snow course measurements within the hydrologic basin or in nearby basins. They are computed as follows:

1. The measured water content at each snow course is adjusted to reflect first of the month conditions (Feb 1, Mar 1, or Apr 1 depending on the date of forecast). Intervening storms are accounted for by using a nearby precipitation station to add an estimated storm amount to measurements taken before the first of the month (or subtracting storm amounts from measurements taken after the first.) The intervening precipitation is multiplied by the ratio of the snow course April 1 average water content in inches divided by the precipitation station's Oct-Mar weighted average.

2. The adjusted snow water content is expressed as a percentage of the April 1 historical average for each snow course.

3. The percentages computed in step 2 are averaged to represent the basin index for the date of forecast expressed as a percentage of the April 1 snowpack.

4. The historical median accumulation between the date of forecast and April 1 is then added to the basin index.

Many basins have a single snow term in which high and low elevation courses are combined. High elevation basins such as those in the Central and Southern Sierra often use 20 or more snow courses.

PRECIPITATION INDEXES

The winter precipitation index OMPT averages station data in much the same way as the snow index term. Precipitation is weighted by month, recognizing that early season storms will contribute less to April-July runoff than those later in the season because soil conditions are generally drier.

Computation steps for winter precipitation are as follows:

1. Monthly precipitation for individual stations is weighted by month:

Month	Weight
Oct	0.5
Nov	0.6
Dec	0.7
Jan	0.8
Feb	0.9
Mar	1.0

2. The sum of the weighted precipitation for each station is expressed as a percentage of the historical October-March weighted average.

3. The percentages for individual stations computed in Step 2 are averaged to represent the current basin index.

4. The median historical accumulation of precipitation from the date of forecast through the end of March is then added to OMPT.

The spring precipitation term AJPT is computed in a similar way after the April 1 forecast using monthly weights of Apr = 1.0, May = 0.8, and Jun = 0.6. Prior to April 1, AJPT is assumed equal to the historical median.

RUNOFF TERMS

The October-March runoff term OMRO is the accumulated flow at the forecast point in thousand acre-feet. The effect of this term is generally small compared to the other terms in the equation.

The prior year runoff term PYRO is the April-July runoff from a year ago and represents carryover storage in the watershed. For most Sierra watersheds, the carryover term is relatively small. For some watersheds, however, particularly those with water bearing volcanic formations such as the Pit River, baseflow is an important component to seasonal runoff and may continue to influence runoff for several years.

FORECAST EXAMPLE

The following figures illustrate typical hydrologic inputs used in the forecast equations. Figure 1 shows a snow index computation for the March 1, 1992 snowmelt forecast for the Yuba River. Each course index is the snow water content in inches divided by the April 1 average and expressed in percent. In this example, no precipitation occurred after the date of measurement and therefore the adjustment to the first of the month was zero. The March 1 basin index is the average of the course indexes. The historical median snow accumulation during March is added to the March 1 index to project conditions to April 1.

Figure 2 shows a precipitation index computation for March 1 conditions. The raw and weighted precipitation are displayed for each month. The lower portion of the table shows computed indexes arranged by the month of forecast. Monthly precipitation index values for future months are flagged with an asterisk.

Figure 3 shows a sample snowmelt runoff computation and the contribution made by each term in the regression equation. The initial forecasts are compared to the historical relationships for nearby watersheds and adjusted if necessary. The final forecast may also be adjusted to account for differences between computed and actual flows during recent months.

Figure 1

**** YUBA RIVER, AT SMARTVILLE ****

92 SNOWPACK INDEX

COURSE NO.	COURSE NAME	AVG 4-1 W.C.	PRECIPITATION STA NO.	PRECIPITATION RATIO	DATE OF MEASURE	FIELD W.C.	INTRV. PRECIP	ADJUSTED W.C.	COURSE INDEX
64	WEBBER PEAK	43.0	10	.90	2-27	21.2	.00	21.2	49
65	CASTLE CREEK 5	51.8	10	1.10	2-27	24.6	.00	24.6	47
66	MEADOW LAKE	55.0	10	1.20	2-26	28.6	.00	28.6	52
68	ENGLISH MOUNTAIN	43.4	10	1.00	2-27	26.1	.00	26.1	60
89	WEBBER LAKE	31.5	10	.70	2-27	17.7	.00	17.7	56
69	DONNER SUMMIT	39.8	10	.90	2-27	19.8	.00	19.8	50
279	EUREKA BOWL	43.8	10	1.00	2-27	24.4	.00	24.4	56
75	CHURCH MEADOWS	31.9	10	.70	2-27	17.4	.00	17.4	55
76	FURNACE FLAT	47.4	10	1.00	2-27	27.0	.00	27.0	57
74	YUBA PASS	31.7	10	.70	2-25	17.6	.00	17.6	56
115	HUYSINK	46.8	10	1.00	2-27	21.2	.00	21.2	45
77	LAKE FORDYCE	40.4	10	.90	2-27	22.0	.00	22.0	54
78	FINDLEY PEAK	28.8	10	.60	2-27	19.2	.00	19.2	67
80	CISCO	26.3	10	.60	2-27	17.4	.00	17.4	66
83	BOWMAN LAKE	21.5	10	.50	2-27	15.8	.00	15.8	73
277	GIBSONVILLE	31.4	10	.70	2-29	25.9	.00	25.9	82
85	LAKE SPAULDING	24.4	10	.50	2-27	14.6	.00	14.6	60

MARCH 1 SNOW PACK INDEX 58

MARCH INCREMENT 11

APRIL 1 SNOW PACK INDEX ESTIMATED AS OF MARCH 1 69 %

Figure 2

YUBA RIVER AT SMARTVILLE

STATION ID	Name	Oct-Mar Avg	October Raw	October Adj	November Raw	November Adj	December Raw	December Adj	January Raw	January Adj	Total ADJ Oct-Jan	Oct-Jan INDEX
DCF	DEER CREEK FOREBAY	45.27	5.72	2.86	4.09	2.45	5.18	3.63	3.56	2.85	11.79	26.0
DWV	DOWNIEVILLE R.S.	39.80	4.23	2.11	3.63	2.18	5.01	3.51	2.92	2.34	10.14	25.5
SPN	LAKE SPAULDING	45.68	5.53	2.76	4.67	2.80	4.72	3.30	2.74	2.19	11.06	24.2
BLC	BLUE CANYON	43.43	6.12	3.06	4.17	2.50	5.13	3.59	3.07	2.46	11.61	26.7
CMV	CAMPTONVILLE RS	38.39	6.88	3.44	3.25	1.95	4.12	2.88	3.20	2.56	10.83	28.2
STV	STRAWBERRY VALLEY	53.40	5.42	2.71	4.16	2.50	7.08	4.96	4.54	3.63	13.79	25.8
BOW	BOWMAN DAM	44.04	6.78	3.39	4.57	2.74	5.09	3.56	1.85	1.48	11.17	25.4
TKE	TRUCKEE RS	20.55	2.50	1.25	2.17	1.30	1.81	1.27	.56	.45	4.27	20.8
SRR	SIERRAVILLE RS	16.34	3.07	1.53	2.35	1.41	1.91	1.34	.37	.30	4.58	28.0
PLE	PLUMAS-EUREKA S.P.	42.99	4.95	2.48	3.95	2.37	4.44	3.11	1.94	1.55	9.51	22.1
											Basin Index Oct-Jan	25.3

YUBA RIVER AT SMARTVILLE

STATION ID	Name	Oct-Mar Avg	February Raw	February Adj	Feb INDEX	March Raw	March Adj	March INDEX
DCF	DEER CREEK FOREBAY	45.27	18.24	16.42	36.3	.00*	.00*	20.0*
DWV	DOWNIEVILLE R.S.	39.80	13.84	12.46	31.3	.00*	.00*	20.0*
SPN	LAKE SPAULDING	45.68	15.25	13.72	30.0	.00*	.00*	20.0*
BLC	BLUE CANYON	43.43	15.71	14.14	32.6	.00*	.00*	20.0*
CMV	CAMPTONVILLE RS	38.39	14.33	12.90	33.6	.00*	.00*	20.0*
STV	STRAWBERRY VALLEY	53.40	22.62	20.36	38.1	.00*	.00*	20.0*
BOW	BOWMAN DAM	44.04	12.29	11.06	25.1	.00*	.00*	20.0*
TKE	TRUCKEE RS	20.55	3.51	3.16	15.4	.00*	.00*	20.0*
SRR	SIERRAVILLE RS	16.34	2.50	2.25	13.8	.00*	.00*	20.0*
PLE	PLUMAS-EUREKA S.P.	42.99	12.66	11.39	26.5	.00*	.00*	20.0*
			Basin Index Feb		28.3	Basin Index Mar		20.0*

INDEXES

Period	February 1	March 1	April 1	May 1	June 1	July 1
October - January	25.3	25.3	25.3			
February	18.0*	28.3	28.3			
March	20.0*	20.0*	20.0*			
October-March	63.3*	73.5*	73.5*			
April				******	******	******
May				27.0*	27.0*	27.0*
June				6.0*	6.0*	6.0*
April-June	90.0*	90.0*	90.0*	******	******	******

Figure 3

Yuba River at Smartville

- **PRECIPITATION INDEX**

OCT.-JAN.	=	25	APRIL	=	57*
FEBRUARY	=	28	MAY	=	27*
MARCH	=	20*	JUNE	=	6*
O-M PPT	=	73	A-J PPT	=	90

- **SNOW PACK INDEX**

MARCH	=	58
MARCH INCREMENT	=	11*
SNOW INDEX	=	69

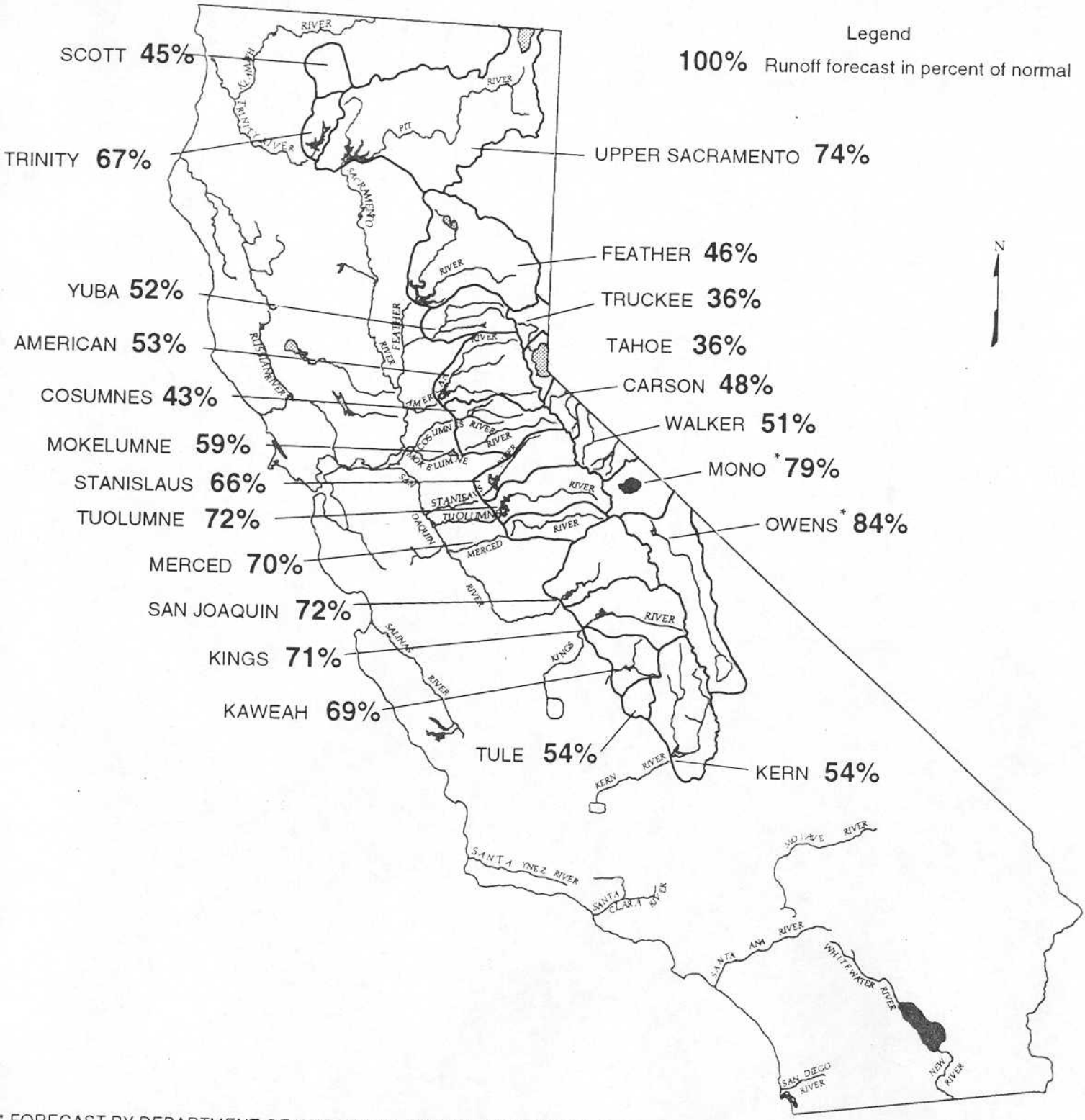
*Median Increment Assumed

$$AJRO = (0.01212)(SNOW)^2 + (3.844)(SNOW) + (0.210)(PYRO) - (8.8 \times 10^{-5})(PYRO)^2 - (0.0813)(OMRO) + (6.481)(O\text{-}M\ PPT) + (22.991)(A\text{-}J\ PPT)^{1/2} + (0.0128)(A\text{-}J\ PPT)^2 - 497.5$$

$(SNOW)^2$	$(69)^2$	X	(0.01212)	=	58
(SNOW)	(69)	X	(3.844)	=	256
(PYRO)	(731)	X	(0.21)	=	154
$(PYRO)^2$	$(731)^2$	X	(-8.8×10^5)	=	-47
(OMRO)	(560)	X	(-0.0813)	=	-46
(O-M PPT)	(73)	X	(6.481)	=	473
$(A\text{-}J\ PPT)^{1/2}$	$(90)^{1/2}$	X	(22.991)	=	218
$(A\text{-}J\ PPT)^2$	$(90)^2$	X	(0.0128)	=	104
			SUM	=	1179
			CONSTANT	=	-497.5
			AJRO	=	682

FORECAST OF APRIL – JULY
UNIMPAIRED SNOWMELT RUNOFF

May 1, 2001



* FORECAST BY DEPARTMENT OF WATER AND POWER, CITY OF LOS ANGELES

WATER SUPPLY FORECASTING

INPUT

* Snow Water Content
* Precipitation - Current Conditions
* Last year's Runoff
* Runoff - Current Conditions
* Historical Snow and Precipitation Accumulation

OUTPUT

Regression Equations

RUNOFF FORECAST

$$AJRO = C1(HSNOW) + C2(LSNOW) + C3(OMPT) + C4(AJPT) + C5(OMRO + C6(PYRO) + K$$

where,

AJRO is April-July runoff in thousand acre-feet

HSNOW is the high elevation April 1 snow index

LSNOW is the low elevation April 1 snow index

OMPT is the October-March precipitation index

AJPT is the April-June precipitation index

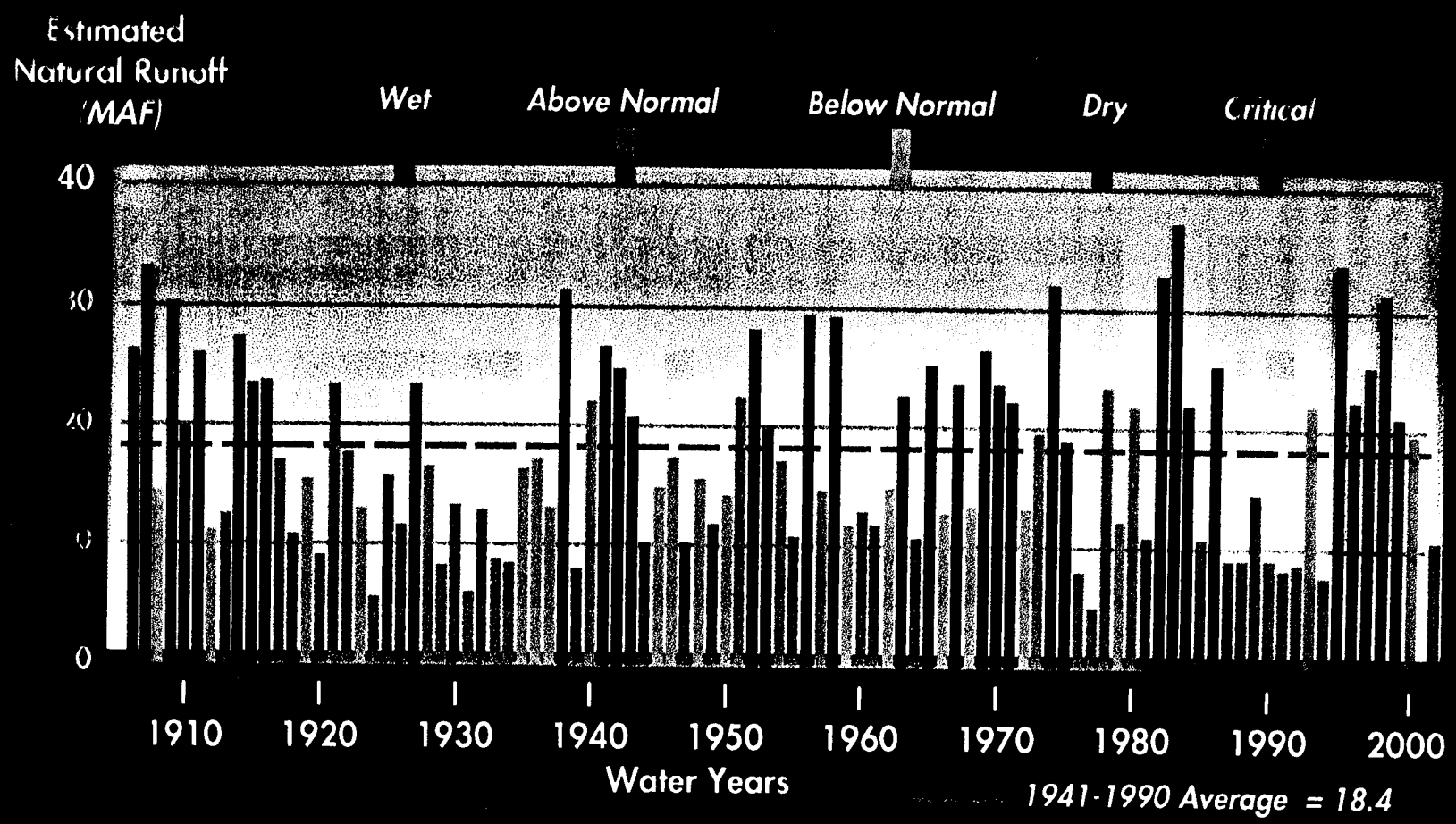
OMRO is the October-March runoff

PYRO is the prior year April-July runoff

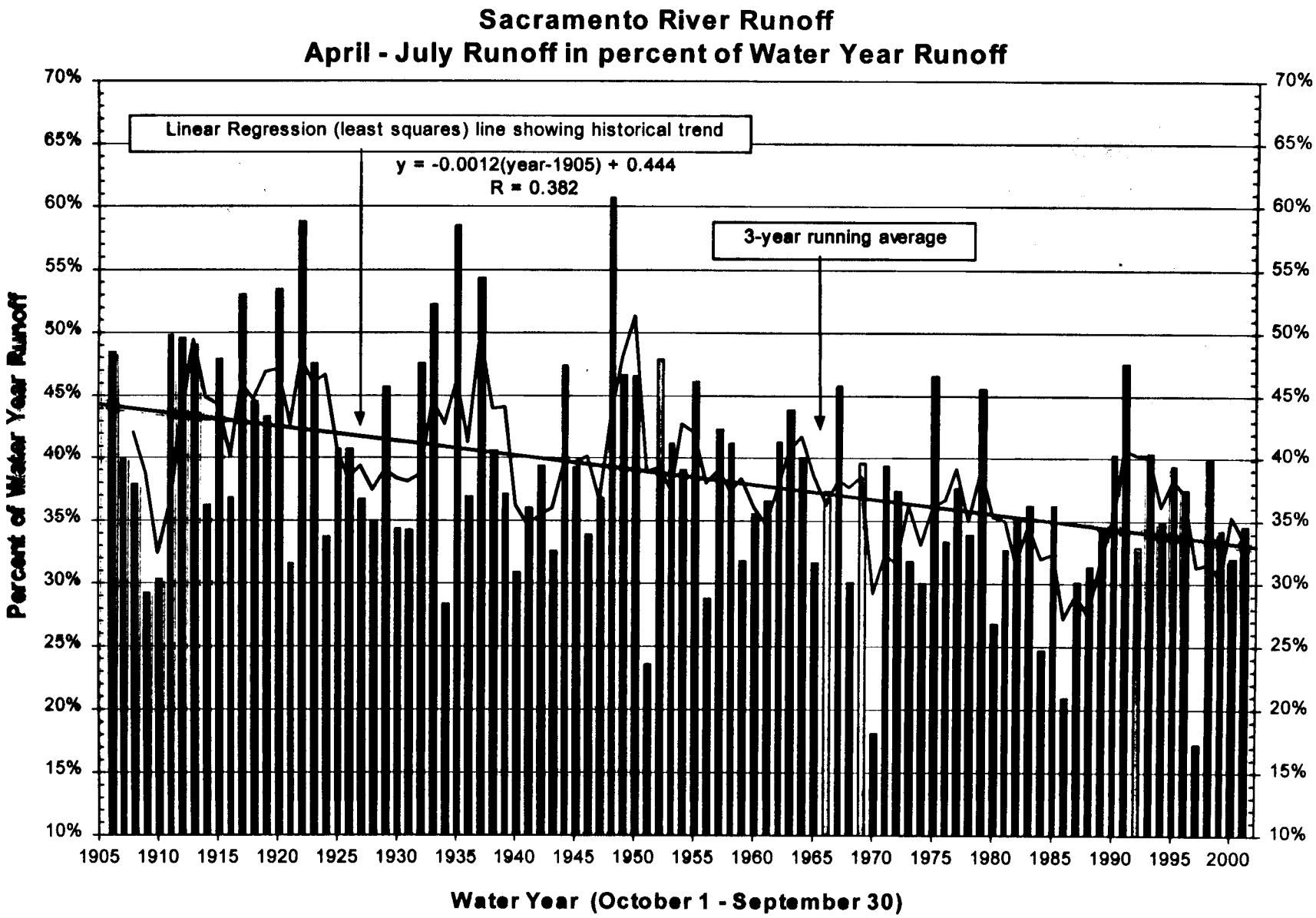
K is a constant

C1 through C6 are fixed coefficients.

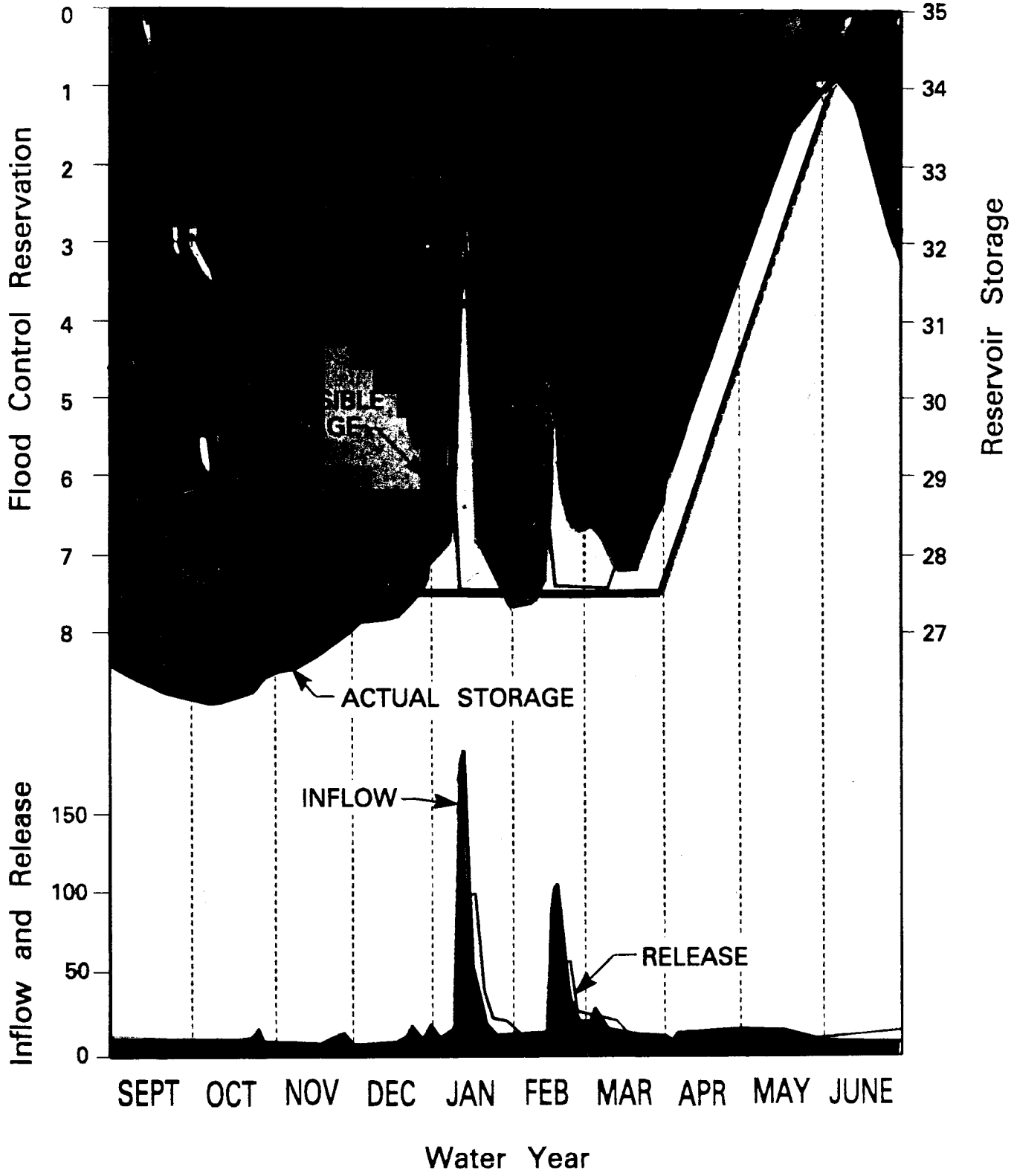
Sacramento River Unimpaired Runoff Since 1906

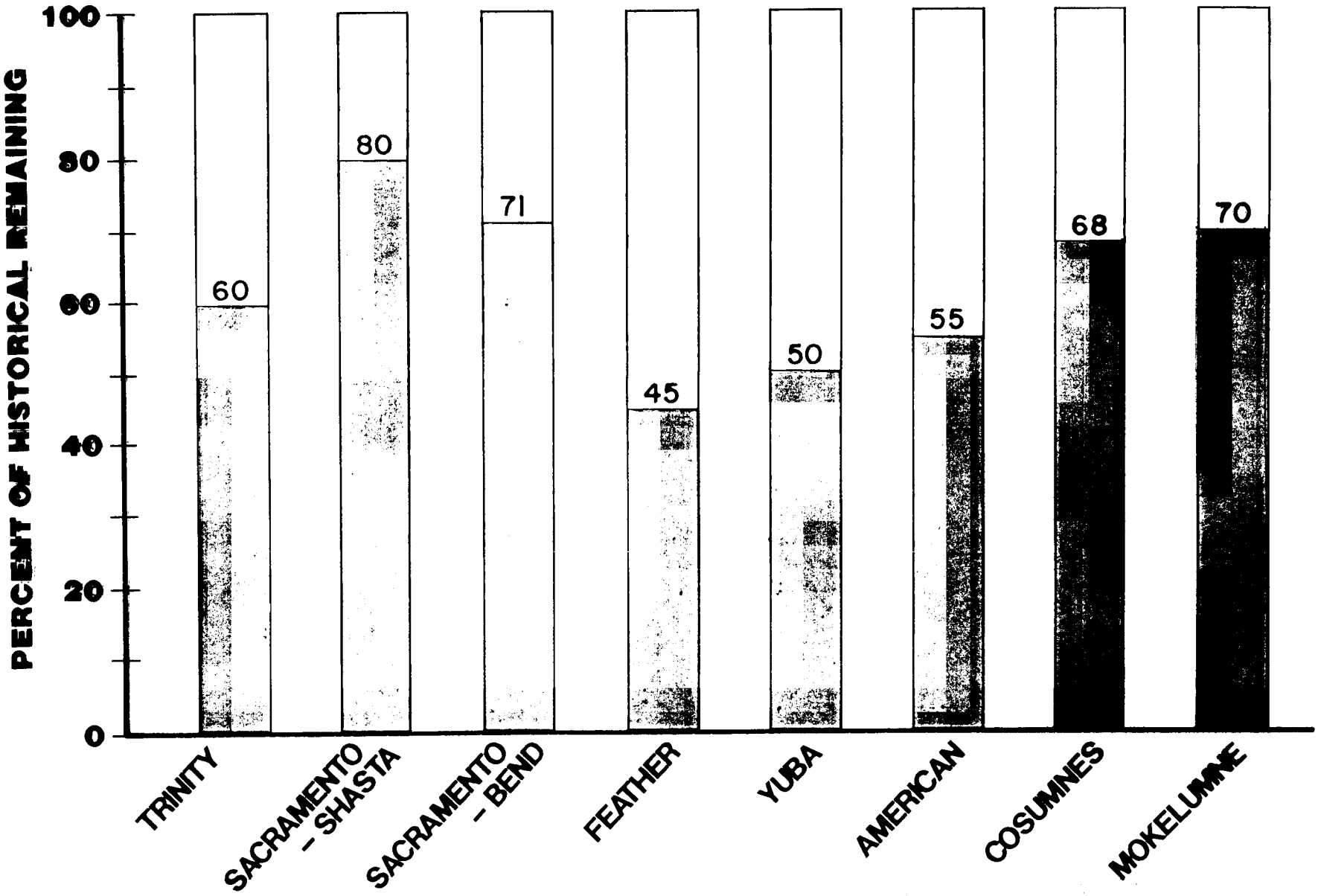


NOTE: The Sacramento River runoff is the sum of unimpaired runoff from the Sacramento River at Bend Bridge, Feather River Inflow to Oroville, Yuba River at Smartville and American River Inflow to Folsom. Categories are based on the 40-30-30 formula.


Sacramento River Runoff
April - July Runoff in percent of Water Year Runoff
Linear Regression (least squares) line showing historical trend
y = -0.0012(year-1905) + 0.444
R = 0.382
3-year running average
Percent of Water Year Runoff
70%
65%
60%
55%
50%
45%
40%
35%
30%
25%
20%
15%
10%
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
Water Year (October 1 - September 30)

TYPICAL EXAMPLE
RESERVOIR FLOOD CONTROL OPERATION



POSSIBLE REDUCTION IN APRIL – JULY RUNOFF WITH 3° C WARMING

NORTHERN HALF