US Army Corps of Engineers
Hydrologic Engineering Center

Generalized Computer Program

RESYLD
Reservoir Yield

User's Manual

August 1966
(revised: November 1981)

CPD-25

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14. ABSTRACT
The purpose of this program is to perform any number of multipurpose routings under identical conditions for a single reservoir with optional delivery to pipe line or river or both and with maximum and minimum flow controls at the reservoir and, if desired, at one downstream control point. This multipurpose reservoir operation-routing or simulation program flows closely the procedures commonly used in hand computation.

15. SUBJECT TERMS
reservoir yield, RESYLD, routing, single reservoir, downstream, control point, storage, simulation, evaporation, power

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US Army Corps of Engineers
Institute for Water Resources
Hydrologic Engineering Center
609 Second Street
Davis, CA 95616

(530) 756-1104
(530) 756-8250 FAX
www.hec.usace.army.mil

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RESERVOIR YIELD

HYDROLOGIC ENGINEERING CENTER
COMPUTER PROGRAM 23-J2-L245

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EXHIBITS

RESERVOIR YIELD

HYDROLOGIC ENGINEERING CENTER
COMPUTER PROGRAM 23-J2-L245

1. ORIGIN OF PROGRAM

This program was prepared in the Hydrologic Engineering Center, Corps of Engineers, 650 Capitol Mall, Sacramento, California, by Leo R. Beard. Up-to-date information and copies of source statement cards for various types of computers can be obtained from the Center upon request by Government and cooperating organizations.

2. PURPOSE OF PROGRAM

a. This generalized program written in Fortran II performs any number of multipurpose routings under identical conditions for a single reservoir with optional delivery to pipe line or river or both and with maximum and minimum flow controls at the reservoir and, if desired, at one downstream control point. Power generation at the reservoir and quality control at the downstream control point are optional. The year is divided into any number of periods (dimensioned up to 15) of equal or unequal length. Maximum and minimum permissible storages and all other quantities can be specified as uniform or varying each period with similar or dissimilar patterns each year. An optional minimum storage above the absolute minimum can be specified at which shortages in withdrawals from storage are declared, increasing linearly to 100 percent at the absolute minimum storage.

b. A listing of the source program and test input and output are given at the end of this report.

3. DESCRIPTION OF EQUIPMENT

While it may be possible to modify this program for use on medium computers of the IBM 1620 and GE 225 with large memory capacity, the program has been tested only on computers of the IBM 7090 class.

4. METHODS OF COMPUTATION

a. This multipurpose reservoir operation-routing or simulation program follows closely the procedures commonly used in hand computation. Where a direct solution is not possible, successive approximations are made.

This is in evaporation and power computation, where the first approximation based on reservoir stage at the beginning of each period is used to establish an approximate average stage for the period, on which the next approximations of evaporation and power are based. Outlet capacity is approximated once only on the basis of reservoir stage at the start of each period. No delay or routing of outflows to the downstream control point is made. Provision is made for an optional buffer zone at the bottom of the conservation pool.

b. The reservoir routing is made by searching for the largest of the minimum flow requirements for all purposes and the smallest of the maximum permissible flows. The release is initially set to the smallest maximum permissible flow. If this does not satisfy the largest minimum flow requirement, the release is increased to do so. These controls are overridden by flows necessary to empty or fill the conservation pool. Absolute control is exercised by full reservoir and empty reservoir limitations. If storage at the start of a period is within the bottom buffer zone, release from the reservoir (over and above inflow minus evaporation) is reduced by the proportion of empty space in the buffer zone. Releases are first assigned to the pipeline and the remainder to the river.

c. Power is generated from all release to the river up to plant capacity. Power generation and release required for power are based on the following equation:

$$P = .08464eQH \qquad (1)$$

where

P = power in kilowatts
e = efficiency as a ratio less than 1
Q = flow in cfs
H = head in feet on power plant

If an efficiency factor is not given (either as a constant or tabulated against reservoir level), a standard value of .86 is used. Head on the power plant is the reservoir stage minus a constant tailwater elevation minus an optional hydraulic loss either expressed in feet or computed as follows:

$$H_L = CQ^2/64.4 \qquad (2)$$

where H_L = hydraulic loss in feet

C = input constant obtainable from chart of ER

Q = Flow in cfs

This head loss is computed only approximately for power release requirement, assuming that outflow required for minimum power generation is met, regardless of other requirements or reservoir storage limitations. Final power generation quantities are based on losses computed from actual river releases and are limited by full generation capacity for the period with a load factor of 1.

d. Water quality computations are based on assumption of complete mixing in the reservoir and river. No provision is made for minimum temperature or concentration control (only maximum). This provision could be added easily, if desired. Water rights are assumed to be limited to reservoir inflow minus channel losses plus local inflow. Releases for quality control are limited by outlet and channel capacities and are curtailed when reservoir concentration exceeds permissible concentration downstream.

e. Shortage indexes computed separately for releases to pipeline and river, for power and for flow at downstream control point (exclusive of water rights) are the sum of squares of annual shortages, each shortage expressed as a ratio to annual requirement, multiplied by the ratio of 100 to the number of years of record.

5. INPUT

a. Input data are summarized in exhibits 5 and 6. All storages are in acre-feet and inflows can be in any units but all inflows must be in the same units of volume or of rate of flow. Required flows can be expressed in cfs or acre-feet, a positive value of IACFT indicating the latter. All flows and required flows are printed out in cfs.

b. It can be noted that features of the program not required for a problem are usually omitted automatically when the variables pertinent to those features are omitted from the input, thus requiring only simple input for simple problems.

c. All data are entered consecutively on each card, using 8 columns (digits, including decimal point, if used) per variable and 10 variables per card unless fewer variables are called for, except that the first column on each card is reserved for identification and not read by computer. Thus, the first field on each card is limited to 7 columns.

6. OUTPUT

All input data except table values are printed out. Status of all variables each month, annual summaries and a summary at the end of each routing are also printed out and identified as illustrated in Exhibit 2. The four shortage indexes are also printed. All storages and evaporation output are in acre-feet, flows and loss in cfs, and power in thousand kw-hr.

7. OPERATING INSTRUCTIONS

Standard Fortran II operating instructions. No sense switches used.

8. DEFINITION OF TERMS

Terms used in this program are defined in Exhibit 3.

9. EXAMPLES

Examples of various applications of this program are given in Exhibits 1 and 2.

10. PROPOSED FUTURE DEVELOPMENT

It is anticipated that additions to or revisions of this program will be made from time to time. It is requested that any user who finds an inadequacy or desirable addition or modification notify the Hydrologic Engineering Center.

SAMPLE INPUT

```
A        CLINTON RESERVIOR
A        EXAMPLE PROBLEM FOR TOPIC 70
A        POWER,M+I, WATER QUALITY,IRRIGATION
B      7    1951      12      10      -1       8       2                2
C 180000              -1      -1      -1      -1      -1      -1       -1      -1
D    100      -1      -1      -1      -1     500     .90     840   100000      -1
E     -1     .05      -2  300000    1.15
F      0    1652   12856   43402   93706  162871  250358  356087
G      0     308    2078    4048    6000    7824    9683   11627
H    820     840     850     860     870     880     890     900
M   1000     700     600     200     130      30       7       0
N      0      .1       4      10     100    1000   10000 1000000
O   1000     300     200     100
P      0     500    1000 1000000
Q     31      30      31      31      28      31      30      31      30      31
Q     31      30
R      5       5       5       5       5       5      10      15      15      15
R     15      10
S      3       3       3       3       3       3       8      10      10      10
S     10       8
T  90000   90000   90000   90000   90000   90000   90000   50000   50000   50000
T  50000   50000
U    400     500     500     400     700     800     900    1100    2200    1600
U    800     600
V  90000   90000   90000   90000   90000   90000   90000   50000   50000   50000
V  50000   50000
W     10      10      10      10      10      10      50      50      50      50
W     50      50
X      2       2       2       2       2       2       4       4       4       4
X      4       4
Y    250     250     250     250     250     250     250     250     200     200
Y    200     200
Z 160000  160000  160000  170000  180000  180000  180000  180000  180000  180000
Z 180000  180000
1  20000   20000   20000   20000   20000   20000   25000   25000   25000   25000
1  20000   20000
2  30000   30000   30000   30000   30000   30000   35000   35000   35000   35000
2  35000   35000
3   -.10    -.10    -.10    -.10    -.10    -.10    -.10    -.10    -.10    -.10
3   -.10    -.10
4      2       2       2       2       2       2       2       2       3       3
```

EXHIBIT 1

EXHIBIT 1

EXHIBIT 2

4	3	3								
5	10	10	10	10	10	10	15	15	15	15
5	15	15								
6	10	1951	106.	14.	12.	13.	26.	47.		
6	10	1951	84.	406.	1610.	3142.	61.	611.	514.	
7	15	1951	15890	4618	3094	2663	3027	5652		
7	15	1951	7561	27620	78870	133200	23390	44660	29350	
6	10	1952	171.	137.	64.	67.	53.	544.		
6	10	1952	630.	159.	24.	3.	2.	0.	154.	
7	15	1952	12200	8644	5211	4901	5074	13660		
7	15	1952	21990	11580	6092	8479	3966	2595	8707	
6	10	1953	0.	0.	1.	1.	1.	5.		
6	10	1953	8.	79.	6.	0.	0.	0.	8.	
7	15	1953	1306	1567	1802	2004	2842	2788		
7	15	1953	2117	3076	4030	2222	1390	941	2168	
6	10	1954	0.	0.	0.	0.	0.	0.		
6	10	1954	0.	10.	131.	2.	34.	0.	14.	
7	15	1954	726	968	1380	820	1191	1032		
7	15	1954	917	2795	12320	1541	8393	1738	2819	
6	10	1955	11.	0.	0.	0.	45.	4.		
6	10	1955	3.	22.	12.	132.	0.	0.	19.	
7	15	1955	1502	874	793	799	3912	2388		
7	15	1955	1882	1614	4201	3260	689	591	1859	
6	10	1956	2.	0.	0.	0.	0.	0.		
6	10	1956	6.	68.	22.	104.	6.	0.	17.	
7	15	1956	2200	637	599	563	809	852		
7	15	1956	845	1028	2190	4499	1093	525	1326	
6	10	1957	0.	0.	0.	0.	0.	4.		
6	10	1957	155.	223.	332.	682.	3.	8.	118.	
7	15	1957	365	504	465	364	635	774		
7	15	1957	2876	8415	18920	15590	5402	5237	4977	
8	1	1951								
6	10	1951	106.	14.	12.	13.	26.	47.		
6	10	1951	84.	406.	1610.	3142.	61.	611.	514.	
7	15	1951	15890	4618	3094	2663	3027	5652		
7	15	1951	7561	27620	78870	133200	23390	44660	29350	

SAMPLE OUTPUT

CLINTON RESERVIOR
EXAMPLE PROBLEM FOR TOPIC 70
POWER,M+I, WATER QUALITY,IRRIGATION

NYRS	IYR	NPER	IPER	NDYS	NSTOR	NCYCL	IACFT	NCPT
7	1951	12	10	-1	8	2	-0	2

STOR1	CONST	QOMN	QMN2	QOMX	QDMN	QDMX	QRTS	EFLT	QULD
180000	1.00	-1	-1	-1	-1	-1	-1	-1	-1

QUR	STMX	STMN	STMN2	PWR	PWRMX	EFFCY	TLWEL	QCAP	EVAP
100	-1	-1	-1	-1	500	.900	840	100000	-1

ALOSS	CLOSS	HYDLS	FULRS	OVLOD
-1	.0500	-2.00000	300000	1.150

EXHIBIT 2

EXHIBIT 2

CYCLE 1

YEAR 1951

PER	CFS INFLOW	END OF MONTH STORAGE IN AC-FT MIN	BUFFER	ACTUAL	MAX	AC-FT EVAP	CFS TO PIPELINE REQ	ACTUAL	SHRTG	RELEASE TO RIVER IN CFS REQ	ACTUAL	SHRTG	RES MAX	CASE	QUAL
10	106	20000	30000	160000	160000	1329	3	3	0	5	407	0	90000	11	102
11	14	20000	30000	158324	160000	1288	3	3	0	5	18	0	90000	6	103
12	12	20000	30000	156513	160000	1280	3	3	0	5	18	0	90000	6	104
1	13	20000	30000	154764	170000	1272	3	3	0	5	18	0	90000	6	106
2	26	20000	30000	153783	180000	1266	3	3	0	5	18	0	90000	6	107
3	47	20000	30000	154124	180000	1265	3	3	0	5	18	0	90000	6	109
4	84	25000	35000	156318	180000	1270	8	8	0	10	18	0	90000	6	111
5	406	25000	35000	178299	180000	1320	10	10	0	15	17	0	50000	6	110
6	1610	25000	35000	270332	180000	2282	10	10	0	15	15	0	50000	5	82
7	3142	25000	35000	300000	180000	2581	10	10	0	15	2608	0	50000	8	58
8	61	20000	35000	180000	180000	2366	10	10	0	15	1964	0	50000	11	60
9	611	20000	35000	180000	180000	2047	8	8	0	10	569	0	50000	11	63
YR	514					19566	6	6	0	9	481	0	73233		

PER	1000 KW-HR POWER REQ	ACTUAL	SHRTG	FLOW IN CFS AT DOWNSTREAM CONTROL POINT QLOCAL	RIGHTS	ADD REQ	ACTUAL	SHRTG	MAX	DOWNSTREAM QUALITY EFLT	REQ	ACTUAL
10	37	428	0	15890	10	400	16267	0	90000	2	250	196
11	36	36	0	4618	10	500	4625	0	90000	2	250	200
12	37	37	0	3094	10	500	3101	0	90000	2	250	200
1	37	37	0	2663	10	400	2670	0	90000	2	250	200
2	34	34	0	3027	10	700	3034	0	90000	2	250	200
3	37	37	0	5652	10	800	5659	0	90000	2	250	200
4	36	36	0	7561	50	900	7564	0	90000	4	250	200
5	37	37	0	27620	50	1100	27622	0	50000	4	250	197
6	36	37	0	78870	50	2200	78870	0	50000	4	200	192
7	37	428	0	133200	50	1600	135663	0	50000	4	200	184
8	37	428	0	23390	50	800	25242	0	50000	4	200	188
9	36	414	0	44660	50	600	45186	0	50000	4	200	194
YR	438	1989	0	29350	30	875	29795	0	73233	3	225	190

NOTE: 1952 - 1956 not shown.

YEAR 1957

PER	CFS INFLOW	END OF MONTH STORAGE IN AC-FT MIN	BUFFER	ACTUAL	MAX	AC-FT EVAP	CFS TO PIPELINE REQ	ACTUAL	SHRTG	RELEASE TO RIVER IN CFS REQ	ACTUAL	SHRTG	MAX	CASE	RES QUAL
10	0	20000	30000	19579	160000	421	3	0	3	5	0	5	90000	10	198
11	0	20000	30000	19163	160000	416	3	0	3	5	0	5	90000	10	202
12	0	20000	30000	18751	160000	412	3	0	3	5	0	5	90000	10	207
1	0	20000	30000	18343	170000	408	3	0	3	5	0	5	90000	10	212
2	0	20000	30000	17940	180000	403	3	0	3	5	0	5	90000	10	216
3	4	20000	30000	17786	180000	400	3	0	3	5	0	5	90000	10	227
4	155	25000	35000	25000	180000	438	8	8	0	10	18	0	90000	10	194
5	223	25000	35000	34577	180000	528	10	10	0	15	49	0	50000	6	169
6	332	25000	35000	50530	180000	998	10	10	0	15	37	0	50000	6	148
7	682	25000	35000	88845	180000	1267	10	10	0	15	28	0	50000	6	112
8	3	20000	35000	85466	180000	1436	10	10	0	15	25	0	50000	6	115
9	8	20000	35000	82562	180000	1406	8	8	0	10	25	0	50000	6	118
YR	118					8534	6	5	1	9	15	2	73233		

PER	1000 KW-HR POWER REQ	ACTUAL	SHRTG	FLOW IN CFS AT DOWNSTREAM CONTROL POINT GLOCAL	RIGHTS	ADD REQ	ACTUAL	SHRTG	MAX	DOWNSTREAM QUALITY EFLT	REQ	ACTUAL
10	37	0	37	365	10	400	365	45	90000	2	250	486
11	36	0	36	504	10	500	504	6	90000	2	250	297
12	37	0	37	465	10	500	465	45	90000	2	250	346
1	37	0	37	364	10	400	364	46	90000	2	250	487
2	34	0	34	635	10	700	635	75	90000	2	250	271
3	37	0	37	774	10	800	774	36	90000	2	250	243
4	36	11	25	2876	50	900	2879	0	90000	4	250	200
5	37	37	0	8415	50	1100	8447	0	50000	4	250	199
6	36	36	0	18920	50	2200	18941	0	50000	4	200	198
7	37	37	0	15590	50	1600	15603	0	50000	4	200	199
8	37	37	0	5402	50	800	5411	0	50000	4	200	200
9	36	36	0	5237	50	600	5247	0	50000	4	200	200
YR	438	195	244	4977	30	875	4984	21	73233	3	225	206

GRAND AVERAGE

PER	CFS INFLOW	END OF MONTH STORAGE IN AC-FT MIN	BUFFER	ACTUAL	MAX	AC-FT EVAP	CFS TO PIPELINE REQ	ACTUAL	SHRTG	RELEASE TO RIVER IN CFS REQ	ACTUAL	SHRTG	MAX	CASE	RES QUAL
YR	121					13783	6	5	1	9	116	1	73233		

PER	1000 KW-HR POWER REQ	ACTUAL	SHRTG	FLOW IN CFS AT DOWNSTREAM CONTROL POINT GLOCAL	RIGHTS	ADD REQ	ACTUAL	SHRTG	MAX	DOWNSTREAM QUALITY EFLT	REQ	ACTUAL
YR	438	961	93	7317	30	875	7417	8	73233	3	225	195

SHORTAGE INDEX, PIPELINE 6.307 OUTLET 6.782 DOWNSTREAM .027 POWER 15.524

EXHIBIT 2

EXHIBIT 2

CYCLE 2

YEAR 1951

PER	CFS INFLOW	END OF MONTH STORAGE IN AC-FT MIN	BUFFER	ACTUAL	MAX	AC-FT EVAP	CFS TO PIPELINE REQ	ACTUAL	SHRTG	RELEASE TO RIVER IN CFS REQ	ACTUAL	SHRTG	MAX	CASE	RES QUAL
10	106	20000	30000	160000	160000	1329	3	3	0	5	407	0	90000	11	119
11	14	20000	30000	158324	160000	1288	3	3	0	5	18	0	90000	6	120
12	12	20000	30000	156513	160000	1280	3	3	0	5	18	0	90000	6	122
1	13	20000	30000	154764	170000	1272	3	3	0	5	18	0	90000	6	123
2	26	20000	30000	153783	180000	1266	3	3	0	5	18	0	90000	6	125
3	47	20000	30000	154124	180000	1265	3	3	0	5	18	0	90000	6	127
4	84	25000	35000	156318	180000	1270	8	8	0	10	18	0	90000	6	128
5	406	25000	35000	178299	180000	1320	10	10	0	15	17	0	50000	6	125
6	1610	25000	35000	270332	180000	2282	10	10	0	15	15	0	50000	5	92
7	3142	25000	35000	300000	180000	2581	10	10	0	15	2608	0	50000	8	64
8	61	20000	35000	180000	180000	2366	10	10	0	15	1964	0	50000	11	66
9	611	20000	35000	180000	180000	2047	8	8	0	10	569	0	50000	11	68
YR	514					19566	6	6	0	9	481	0	73233		

PER	1000 KW-HR POWER REQ	ACTUAL	SHRTG	FLOW IN CFS AT DOWNSTREAM CONTROL POINT QLOCAL	RIGHTS	ADD REQ	ACTUAL	SHRTG	MAX	DOWNSTREAM QUALITY EFLT	REQ	ACTUAL
10	37	428	0	15890	10	400	16267	0	90000	2	250	197
11	36	36	0	4618	10	500	4625	0	90000	2	250	200
12	37	37	0	3094	10	500	3101	0	90000	2	250	200
1	37	37	0	2663	10	400	2670	0	90000	2	250	200
2	34	34	0	3027	10	700	3034	0	90000	2	250	200
3	37	37	0	5652	10	800	5659	0	90000	2	250	200
4	36	36	0	7561	50	900	7564	0	90000	4	250	200
5	37	37	0	27620	50	1100	27622	0	50000	4	250	197
6	36	37	0	78670	50	2200	78870	0	50000	4	200	192
7	37	428	0	133200	50	1600	135663	0	50000	4	200	185
8	37	428	0	23390	50	800	25242	0	50000	4	200	188
9	36	414	0	44660	50	600	45186	0	50000	4	200	194
YR	438	1989	0	29350	30	875	29795	0	73233	3	225	190

GRAND AVERAGE

PER	CFS INFLOW	END OF MONTH STORAGE IN AC-FT MIN	BUFFER	ACTUAL	MAX	AC-FT EVAP	CFS TO PIPELINE REQ	ACTUAL	SHRTG	RELEASE TO RIVER IN CFS REQ	ACTUAL	SHRTG	MAX	CASE	RES QUAL
YR	514					19566	6	6	0	9	481	0	73233		

PER	1000 KW-HR POWER REQ	ACTUAL	SHRTG	FLOW IN CFS AT DOWNSTREAM CONTROL POINT QLOCAL	RIGHTS	ADD REQ	ACTUAL	SHRTG	MAX	DOWNSTREAM QUALITY EFLT	REQ	ACTUAL
YR	438	1989	0	29350	30	875	29795	0	73233	3	225	190

SHORTAGE INDEX, PIPELINE 0. OUTLET 0. DOWNSTREAM 0. POWER .000

DEFINITIONS - 23-J2-L245

*ALOS - Constant loss component between reservoir and downstream control point, for each period, in cfs.

ALOSS - Constant loss component between reservoir and downstream control point, for all periods in cfs. Calling index if negative.

*ALSA - Total loss for each period between reservoir and downstream control point in cfs.

ANDYS - NDAYS

*AREA - Reservoir area in acres in table

AREAA - Reservoir area in acres at middle of period (approx)

CLOSS - Loss coefficient applied to flow remaining after ALOS is subtracted to obtain remaining loss between reservoir and downstream control point

CNST - Conversion factor from cfs for period to thousand cfs-hours

CNSTA - Factor to convert inflows to cfs

CNSTB - Conversion factor from cfs for period to acre-feet

CNSTC - Conversion factor from acre-feet to cfs for period

CONST - Conversion factor from inflow units to acre-feet, if flow units are volumes and from inflow units per day to cfs if flow units are rates.

CPWR - Coefficient multiplied by product of flow in cfs and head in feet to obtain power in kw.

CT - Converts flows for each period to obtain average for year

*EFCY - Plant efficiency ratio in table

EFFCY - Plant efficiency ratio, calling index if negative

EFLNT - Effluent in tons per day discharged into river between reservoir and downstream control point, calling index if negative

EFLT - Effluent in tons per day discharged for one period into river between reservoir and downstream control point

*EL - Reservoir elevation in storage table in feet

*ELEFY - Reservoir elevation in efficiency table in feet

EVAP - Reservoir evaporation net change to project conditions in inches per year, calling index if negative.

EVAPA - Reservoir evaporation (net change to project conditions) for period in acre-feet

*EVAPO - Reservoir evaporation (net change to project conditions) in inches for period

*EVP - Subscripted value of EVAPA

HEAD - Power head in feet

HYDLS - Hydraulic head loss, coefficient in equation $H_{LOSS} = (HYDLS)Q^2/2g$ if positive, loss in feet if negative

I - Subscript for period

IACFT - Positive value calls for flow requirements in acre-feet

ICASE - Case number

1. Release restricted by outlet capacity
2. Release restricted by channel capacity at dam

* Subscripted variable

EXHIBIT 3

3. Release restricted by downstream channel capacity
4. Release to satisfy downstream water requirements
5. Release to satisfy water requirements at dam
6. Release to satisfy power requirements
7. Release to satisfy quality requirements
8. Release required to prevent over-filling reservoir
9. Release controlled by declared shortage
10. Release restricted by bottom of conservation pool
11. Release for flood control

ICSE - Tentative case number
IFLNT - EFLNT
IHOGN - Positive value calls for special criteria for New Hogan Reservoir
IPER - Number of first period in each year
*IQUR - Reservoir quality at end of period
IYR - Year number
IX - Temporary variable
J - Year subscript
K - Table subscript
*M - Period identification number
NC - Number of cycles completed
NCYCL - Number of cycles (complete routings) for job.
*NDAYS - Number of days in a period
NDYS - Number of days in each period if same for all periods, calling index if negative.
NPER - Number of routing periods per year
NSTOR - Number of storage values in table
NYRS - Number of years in each routing
*POWER - Power in thousand kw-hr actually generated in one period
*POWR - Minimum power in thousand kw-hr required in one period if positive, average load factor if negative.
PWR - Minimum power in thousand kw-hr required per period if same for all periods, calling index if negative.
PWRMX - Maximum permissible generation in kw.
Q - Actual reservoir release for period
QALI - Quality of inflow to reservoir in parts per million or degrees.
QALL - Quality of local inflow in parts per million or degrees.
QCAP - Outlet capacity in cfs.
*QD - Actual flow at downstream control point, including all water rights
*QDMAX - Maximum permissible flow for period at downstream control point, including all water rights
*QDMIN - Minimum permissible flow for period at downstream control point, excluding water rights.
QDMN - Minimum permissible flow at downstream control point for each period if same for all periods, excluding water rights, calling index if negative.
QDMX - Maximum permissible flow at downstream control point for each period if same for all periods, including water rights, calling index if negative.

* Subscripted variable

EXHIBIT 3

*QI - Inflow to reservoir for period (See input data for units)
*QIQUA - Reservoir inflow in water quality table in cfs
*QL - Local inflow for period (See input table for units)
*QLQUA - Local inflow in water quality table in cfs
QMAX - Successive control value of maximum required outflow in cfs
QMIN - Successive control value of minimum required outflow in cfs
QMN2 - Minimum required outflow to pipeline for each period if same for all periods (See input data for units), calling index if negative.
QMX - Flow in cfs required to empty conservation space during period
*QOCAP - Table value of outlet capacity in cfs
*QOMAX - Maximum permissible outflow in cfs to river for period
*QOMIN - Minimum required outflow to river for period (See input data for units)
QOMN - Minimum required outflow to river for each period if same for all periods (See input data for units), calling index if negative.
*QOMN2 - Minimum required outflow to pipeline for each period (See input data for units).
QOMX - Maximum permissible outflow in cfs to river for each period if same for all periods, calling index if negative
*QOSTR - Table value of storage in acre-feet for outlet capacity determination
QPIPE - Actual reservoir release in cfs to pipeline for period
*QRITS - Maximum water right for period, see input data for units
QRIVR - Actual reservoir release in cfs to river for period
*QRT - Actual water right in cfs for period
QRTS - Maximum water rights for each period if same for all periods (See input data for units), calling index if negative
*QUALD - Required minimum quality for period at downstream control point (Maximum temperature or concentration in parts per million).
*QUALI - Quality of reservoir inflow for period in parts per million or degrees.
*QUALL - Quality of local inflow for period in parts per million or degrees
QULD - Minimum required quality at downstream control point for each period if same for all periods, in parts per million or degrees, calling index, if negative
*QULTD - Actual quality attained at downstream control point in parts per million or degrees
*QUR - Reservoir quality for period in parts per million or degrees
RNYRS - Reciprocal of NYRS
SAMN - Average required outflow in cfs to pipeline for all years
SBMN - Average required outflow in cfs to river for all periods
SDMN - Average required flow in cfs at downstream control point for all years
SDMX - Average maximum flow in cfs at downstream control point for all years
SEFT - Average annual effluent in tons per day
SEVP - Total evaporation in acre-feet per year for entire routing
SHOGN - Sum of May-Oct requirements for New Hogan Reservoir
SHRTA - Shortage to pipeline for period

* Subscripted variable

EXHIBIT 3

*SHRTD - Shortage of flow in cfs at downstream control point for period
*SHRTP - Shortage of power in kw-hr for period
SHRTB - Shortage of outflow in cfs to river for period
SI - Average annual inflow in cfs for routing
SINDA - Sum of squares of annual shortages to pipeline, each expressed as ratio to annual requirement
SINDB - Sum of squares of annual shortages to river, each expressed as ratio to annual requirement
SINDD - Sum of squares of annual shortages to combined water rights and downstream control point requirements, each shortage expressed as ratio to annual requirement.
SINDP - Sum of squares of annual power shortages, each expressed as ratio to annual requirement
SL - Average annual local inflow in cfs for routing
SLOS - Average annual channel loss for routing
SMAMN - Total required outflow to pipeline in one year
SMBMN - Total required outflow to river for one year
SMOMN - Total required flow at downstream control point, excluding water rights, for one year
SMEFT - Average daily effluent in tons for one year
SMEVP - Evaporation in acre-feet for one year
SMI - Total reservoir inflow for one year
SML - Total local inflow for one year
SMLOS - Sum of loss in cfs in downstream channel for year.
SMPMN - Sum of power requirement in thousand kw-hr for one year.
SMPWR - Sum of power generated during year in thousand kw-hr.
SMQAL - Average quality at downstream control point for one year (degrees or parts per million)
SMQD - Sum of flow in cfs at downstream control point for one year.
SMQOA - Total outflow in cfs to pipeline for one year.
SMQOB - Total outflow in cfs to river for one year.
SMRTS - Total water rights in cfs for one year.
SMSHA - Sum of shortages in cfs to pipeline for one year.
SMSHB - Sum of shortages in cfs to river for one year.
SMSHD - Sum of shortages in cfs in supply at downstream control point for one year.
SMSHP - Sum of power shortages in kw-hr for one year.
SPWR - Average power generation per year for routing in thousand kw-hr.
SPMN - Average annual minimum power requirements in thousand kw-hr.
SQAL - Average quality in parts per million or degrees at downstream control point for routing.
SQD - Average annual flow in cfs at downstream control point for routing
SQMX - Average of maximum flows in cfs to river for each year and for entire routing
SQOA - Average annual actual flow in cfs to pipeline for routing
SQOB - Average minimum required outflow in cfs to river for all years.
SQUMN - Average quality required at downstream control point for each year and for entire routing (degrees or parts per million).
SRTS - Average water rights for routing.
SSHA - Average annual shortage of required outflow in cfs to pipeline for entire routing.

* Subscripted variable

EXHIBIT 3

SSHB - Average annual shortage in cfs to river for entire routing
SSHD - Average annual shortage in cfs at downstream control point for entire routing.
SSHP - Average annual power shortage in kw-hr for entire routing
STMN - Minimum storage in acre-feet for each period if same for all periods, calling index if negative.
STMN2 - Storage in acre-feet equal to or greater than STMN below which shortage is declared, for each period if same for all periods, calling index if negative.
STMX - Maximum storage in acre-feet for each period if same for all periods, calling index if negative.
*STOR - Table storage in acre-feet
STOR1 - Storage in acre-feet at start of routing cycle.
STORA - Storage in acre-feet at start of period.
*STORB - Storage in acre-feet at end of period.
STRAV - Average storage in acre-feet for period
*STRM2 - Storage in acre-feet for each period equal to or greater than STRMN at which shortages are declared.
*STRMN - Minimum storage in acre-feet for each period
*STRMX - Maximum storage in acre-feet for each period
TEMP - Temporary variable
TLWEL - Tailwater elevation in feet.
TMP - Temporary variable

* Subscripted variable

Added variables:

NCMP - Number of complete computations to be made each period for successive approximations of power, evaporation and reservoir quality
NCOMP - Number of complete computations finished during current period

SOURCE PROGRAM LISTING

```
C       23-J2-J245 RESERVOIR YIELD  HYDROLOGIC ENGR CTR  29 JULY 66
        DIMENSION NDAYS(15),STOR(40),AREA(40),EL(40),POWR(15),QOCAP(10),
       2QRITS(15),EFLNT(15),QUALD(15),QUALI(10),QIQUA(10),QUALL(10),
       3QLQUA(10),STRMX(15),STRMN(15),STRM2(15),EVAPO(15),QI(15),QL(15),
       4SHRTD(15),SHRTP(15), POWER(15),ALOS(15),QUR(16),ALSA(15)
        DIMENSION EFCY(10),ELEFY(10),QULTD(15),QD(15) ,M(15),STORB(15),
       2QOSTR(10),QOMIN(15),QOMN2(15),QOMAX(15),QDMIN(15),QDMAX(15),
       3QRT(15)
        KSTOR=40
        KPER=15
C                              THREE OUTPUT TITLE CARDS
   10 PRINT 20
   20 FORMAT (1H1)
      READ 30,(STOR(I),AREA(I),EL(I),I=1,40)
      PRINT 30,(STOR(I),AREA(I),EL(I),I=1,40)
   30 FORMAT (1X,A1,39A2)
      PRINT 40
   40 FORMAT(/78H  OUTPUT FLOWS IN CFS, END-OF-MONTH STORAGES IN AC-FT,
     1POWER IN THOUSAND KW-HR)
C       READ KEY DATA AND INITIATE VARIABLES
      READ 80,NYRS,IYR,NPER,IPER,NDYS,NSTOR,NCYCL,IACFT,NCMP
      IF (NPER-KPER) 43,43,45
   43 IF (NSTOR-KSTOR) 49,49,45
   45 PRINT 47
   47 FORMAT (19H DIMENSION EXCEEDED)
      STOP
   49 IF(NYRS)50,50,60
   50 STOP
   60 READ70,STOR1,CONST,QOMN,QMN2,QOMX,QDMN,QDMX,QRTS,EFLT,QULD,QUR(1),
     1STMX,STMN,STMN2,PWR,PWRMX,EFFCY,TLWEL,QCAP,EVAP,ALOSS,CLOSS,HYDLS,
     2FULRS,OVLOD
   70 FORMAT (1X,F7.0,9F8.0)
   80 FORMAT (1X,I7,9I8)
      NC = 0
      QALI = 0.
      IF(CONST)100,90,100
   90 CONST=1.
  100 IF (OVLOD)110,110,120
  110 OVLOD = 1.
  120 IF(FULRS)130,130,140
  130 FULRS=99999999.
```

EXHIBIT 4

EXHIBIT 4

```
      READ70,(STOR(K),K=1,NSTOR)
      READ70,(AREA(K),K=1,NSTOR)
      IF(PWR)150,160,150
  150 READ70,(EL(K),K=1,NSTOR)
  160 DO 180 I=1,NPER
      NDAYS(I) = NDYS
      QOMIN(I) = QOMN
      QOMN2(I) = QMN2
      QOMAX(I) = QOMX
      QDMIN(I) = QDMN
      QDMAX(I) = QDMX
      QRITS(I) = QRTS
      EFLNT(I) = EFLT
      QUALD(I) = QULD
      STRMX(I) = STMX
      STRMN(I) = STMN
      STRM2(I) = STMN2
      POWR(I) = PWR
      ALOS(I)=ALOSS
      QL(I)=0.
      POWER(I)=0.
      SHRTP(I)=0.
      QUR(I+1)=0.
      ALSA(I)=0.
      QD(I)=0.
      SHRTD(I)=0.
      M(I)=IPER+I-1
      IF(M(I)-NPER)180,180,170
  170 M(I)=M(I)-NPER
  180 QULTD(I)=0.
      PRINT 190
  190 FORMAT(/72H    NYRS      IYR     NPER     IPER     NDYS    NSTOR    NCYC
     1L    IACFT     NCPT)
      QOCAP(1) = QCAP
      QOCAP(2) = QCAP
      QOSTR(1) = 0.
      QOSTR(2) = 99999999.
      IF(QCAP)200,200,210
  200 READ70,(QOCAP(K),K=1,10)
      READ70,(QOSTR(K),K=1,10)
  210 IF(EFFCY)220,230,240
```

```
  220 READ70,(EFCY(K),K=1,10)
      READ 70,(ELEFY(K),K=1,10)
      GO TO 250
  230 EFFCY=.8633
  240 EFCY(1)=EFFCY
      EFCY(2)=EFFCY
      ELEFY(1)=0.
      ELEFY(2)=999999.
C     READ INFLOW AND OUTFLOW QUALITY TABLES
  250 IF(QUR(1))290,290,260
  260 READ70,(QUALI(K),K=1,10)
      READ70,(QIQUA(K),K=1,10)
      IF(QULD) 280,290,280
  280 READ70,(QUALL(K),K=1,10)
      READ70,(QLQUA(K),K=1,10)
  290 IF(QOMX)320,300,320
  300 DO 310 I=1,NPER
  310 QOMAX(I) =   999999.
  320 IF(QDMX)350,330,350
  330 DO 340 I=1,NPER
  340 QDMAX(I) = 999999.
  350 PRINT80,NYRS,IYR,NPER,IPER,NDYS,NSTOR,NCYCL,IACFT,NCMP
      PRINT 360
  360 FORMAT (/75H     STOR1    CONST    QOMN    QMN2     QOMX    QDMN     QDMX
     1   QRTS    EFLT    QULD)
      PRINT 370,STOR1,CONST,QOMN,QMN2,QOMX,QDMN,QDMX,QRTS,EFLT,QULD
  370 FORMAT(F9.0,F8.2,2F7.0,F8.0,F7.0,F8.0,3F7.0)
      PRINT 380
  380 FORMAT(/74H   QUR      STMX      STMN     STMN2      PWR    PWRMX EFFCY
     1 TLWEL     QCAP EVAP)
      PRINT 390,QUR(1),STMX,STMN,STMN2,PWR,PWRMX,EFFCY,TLWEL,QCAP,EVAP
  390 FORMAT(F6.0,3F9.0,2F8.0,F6.3,F6.0,F8.0,F5.0)
      PRINT 400
  400 FORMAT(/37H ALOSS CLOSS    HYDLS     FULRS    OVLOD)
      PRINT 410,ALOSS,CLOSS,HYDLS,FULRS,OVLOD
  410 FORMAT(F6.0,F8.4,F8.5,F9.0,F8.3)
      N = 0
C     RE-ENTRY FOR NEW CYCLE
  420 STORA=STOR1
      IF (NC-1)440,430,430
  430 READ 80,NYRS,IYR
```

EXHIBIT 4

EXHIBIT 4

```
  440 NC = NC + 1
C     INITIATE CYCLE SUMS
      TEMP=NYRS
      RNYRS=1./TEMP
      SBMN=0.
      SAMN=0.
      SQMX= 0.
      SDMN=0.
      SDMX=0.
      SRTS=0.
      SEFT=0.
      SQUMN=0.
      SPMN=0.
      SEVP = 0.
      SSHA=0.
      SSHB=0.
      SI =0.
      SL =0.
      SQOB=0.
      SQOA= 0.
      SPWR=0.
      SSHP=0.
      SLOS=0.
      SQD=0.
      SSHD=0.
      SQAL=0.
      SINDA=0.
      SINDB=0.
      SINDD=0.
      SINDP=0.
      PRINT 20
      PRINT 450,NC
  450 FORMAT(/6H CYCLE,I3)
      DO 2180 J=1,NYRS
C                 AFTER FIRST YEAR OF FIRST CYCLE, N=1. FIRST YEAR N=0
      AN = N
      IF(NDYS+N)460,470,470
  460 READ80,(NDAYS(I),I=1,NPER)
  470 SMDYS=0.
      DO 480 I=1,NPER
      ANDYS=NDAYS(I)
```

```
480 SMDYS=SMDYS+ANDYS
    IF(QOMN+AN)490,485,485
485 IF(N)495,495,520
490 READ 70,(QOMIN(I),I=1,NPER)
495 IF(IACFT)520,520,500
500 DO 510 I=1,NPER
    ANDYS=NDAYS(I)
510 QOMIN(I)=QOMIN(I)/(1.9835*ANDYS)
520 IF(QMN2+AN)530,525,525
525 IF(N)535,535,560
530 READ70,(QOMN2(I),I=1,NPER)
535 IF(IACFT)560,560,540
540 DO 550 I=1,NPER
    ANDYS=NDAYS(I)
550 QOMN2(I)=QOMN2(I)/(1.9835*ANDYS)
560 IF(QOMX+AN)570,580,580
570 READ70,(QOMAX(I),I=1,NPER)
580 IF(QDMN+AN)590,585,585
585 IF(N)595,595,620
590 READ 70,(QDMIN(I),I=1,NPER)
595 IF(IACFT)620,620,600
600 DO 610 I=1,NPER
    ANDYS=NDAYS(I)
610 QDMIN(I)=QDMIN(I)/(1.9835*ANDYS)
620 IF(QDMX+AN)630,640,640
630 READ70,(QDMAX(I),I=1,NPER)
640 IF(QRTS+AN)650,645,645
645 IF(N)655,655,680
650 READ 70,(QRITS(I),I=1,NPER)
655 IF(IACFT)680,680,660
660 DO 670  I=1,NPER
    ANDYS=NDAYS(I)
670 QRITS(I)=QRITS(I)/(1.9835*ANDYS)
680 IF(EFLT+AN)690,700,700
690 READ 70,(EFLNT(I),I=1,NPER)
700 IF(QULD+AN)710,720,720
710 READ70,(QUALD(I),I=1,NPER)
720 IF(STMX+AN)730,740,740
730 READ 70,(STRMX(I),I=1,NPER)
740 IF(STMN+AN)750,760,760
750 READ 70,(STRMN(I),I=1,NPER)
```

EXHIBIT 4

EXHIBIT 4

```
      760 IF(STMN2+AN)770,780,780
      770 READ 70,(STRM2(I),I=1,NPER)
      780 IF(PWR+AN) 790,800,800
      790 READ 70,(POWR(I),I=1,NPER)
      800 IF(EVAP+AN)810,820,820
      810 READ 70,(EVAPO(I),I=1,NPER)
      820 IF(ALOSS+AN)830,840,840
      830 READ 70,(ALOS(I),I=1,NPER)
      840 IF(EVAP)870,850,850
      850 DO 860 I=1,NPER
          IF(STRM2(I)-STRMN(I))854,856,856
      854 STRM2(I)=STRMN(I)
      856 TEMP = NDAYS(I)
          TEMP=TEMP/SMDYS
      860 EVAPO(I) = EVAP*TEMP
      870 READ 890,(QI(I),I=1,NPER)
          N = 1
          IF(QDMN)880,900,880
      880 READ 890,(QL(I),I=1,NPER)
        C     INITIATE ANNUAL SUMS
      890 FORMAT(16X,6F8.0)
      900 SMBMN=0.
          SMAMN=0.
          SMQMX=0.
          SMDMN=0.
          SMDMX=0.
          SMRTS=0.
          SMEFT=0.
          SMQMN = 0.
          SMPMN=0.
          SMEVP=0.
          SMSHA=0.
          SMSHB=0.
          SMI   =0.
          SML   =0.
          SMQOB=0.
          SMQOA=0.
          SMPWR=0.
          SMSHP=0.
          SMLOS=0.
          SMQD=0.
```

```
      SMSHD=0.
      SMQAL=0.
C               PRINT HEADINGS, START PERIOD COMPUTATION
      PRINT 970,IYR
  970 FORMAT(//5H YEARI5)
      PRINT 980
  980 FORMAT(/7X,3HCFS14X,13HAC-FT STORAGE12X,5HAC-FT5X,15HCFS TO PIPELI
     1NE10X,17HCFS RIVER RELEASE12X,3HRES)
      PRINT 990
  990 FORMAT(116H PER INFLOW      MIN   BUFFER   ACTUAL       MAX   EVAP
     1   REQ ACTUAL  SHRTG      REQ  ACTUAL   SHRTG    MAX CASE QUAL)
      DO 2090 I=1,NPER
      STRAV=STORA
      EVAPA=0.
      ANDYS = NDAYS(I)
      CNSTA= CONST
      IF(CONST)1000,1000,1020
 1000 CNSTA=(-CONST)/(1.9835*ANDYS)
 1020 CNST = .024*ANDYS
      QI(I) = QI(I)*CNSTA
      QL(I) = QL(I)*CNSTA
      CNSTB = 1.9835*ANDYS
      CNSTC = 1./CNSTB
      CT = ANDYS/SMDYS
      IF(POWR(I))1030,1040,1040
 1030 POWR(I) = POWR(I)*PWRMX*(-CNST)
 1040 NCOMP =1
C     OUTLET CAPACITY
 1050 DO 1080 L=2,10
      K=L
 1060 IF(STRAV-QOSTR(K))1110,1110,1070
 1070 IF(QOSTR(K)-QOSTR(K-1))1090,1090,1080
 1080 CONTINUE
      GO TO 1091
 1090 K=K-1
 1091 PRINT 1100
 1100 FORMAT(32H OPERATING BEYOND RANGE OF TABLE)
 1110 QMAX = (QOCAP(K)-QOCAP(K-1))*(STORA-QOSTR(K-1))/(QOSTR(K)-QOSTR(K-
     11))+QOCAP(K-1)+QOMN2(I)
      ICASE = 1
C     CHANNEL CAPACITY AT DAM
```


EXHIBIT 4

```
      IF(QMAX-QOMAX(I)-QOMN2(I))1130,1130,1120
 1120 QMAX = QOMAX(I)+QOMN2(I)
      ICASE=2
C     CHANNEL CAPACITY AT DOWNSTREAM CONTROL POINT
 1130 IF((QMAX-ALOS(I)-QOMN2(I))*(1.-CLOSS)+QL(I)-QDMAX(I))1150,1150,114
     10
 1140 QMAX = (QDMAX(I)-QL(I))/(1.-CLOSS)+QOMN2(I)+ALOS(I)
      ICASE=3
 1150 QRT(I)=QRITS(I)
C     WATER RIGHTS AND SUPPLY TO DOWNSTREAM CONTROL POINT
      IF(QRT(I)-(QI(I)-ALOS(I))*(1.-CLOSS)-QL(I))1154,1154,1152
 1152 QRT(I)=(QI(I)-ALOS(I))*(1.-CLOSS)+QL(I)
      IF (QRT(I)) 1153,1154,1154
 1153 QRT(I) = 0.
C              DOWNSTREAM REQUIREMENT
 1154 QMIN = (QDMIN(I)+QRT(I)-QL(I))/(1.-CLOSS)+ALOS(I)+QOMN2(I)
      ICSE=4
C     MINIMUM REQUIRED OUTFLOW
      IF(QMIN-QOMIN(I)-QOMN2(I))1180,1190,1190
 1180 QMIN = QOMIN(I)+QOMN2(I)
      ICSE = 5
C     MINIMUM POWER GENERATION
 1190 IF(PWR)1200,1310,1200
 1200 DO 1210 L=2,NSTOR
      K=L
      IF(STRAV-STOR(K))1230,1230,1205
 1205 IF(STOR(K)-STOR(K-1))1225,1225,1210
 1210 CONTINUE
      GO TO 1226
 1225 K = K - 1
 1226 PRINT 1100
 1230 TMP=(EL(K)-EL(K-1))*(STRAV-STOR(K-1))/(STOR(K)-STOR(K-1))+EL(K-1)
      HEAD=TMP-TLWEL
      TEMP=(-HYDLS)
      IF(HYDLS)1260,1260,1250
 1250 TEMP=POWR(I)/(HEAD*CPWR)
      TEMP=HYDLS*TEMP*TEMP*.01553
 1260 HEAD=HEAD-TEMP
      DO 1270 L=2,10
      K=L
      IF(ELEFY(K)-TMP)1265,1290,1290
```

```
 1265 IF(ELEFY(K)-ELEFY(K-1))1285,1285,1270
 1270 CONTINUE
      GO TO 1286
 1285 K = K - 1
 1286 PRINT 1100
 1290 TMP=(TMP-ELEFY(K-1))*(EFCY(K)-EFCY(K-1))/(ELEFY(K)-ELEFY(K-1))+EFC
     1Y(K-1)
      CPWR=TMP*.08464*CNST
      TEMP=POWR(I)/(HEAD*CPWR)+QOMN2(I)
      IF(QMIN-TEMP)1300,1310,1310
 1300 QMIN = TEMP
      ICSE=6
C     MINIMUM QUALITY AT DOWNSTREAM CONTROL POINT
 1310 IF (QUR(1))1420,1420,1320
 1320 DO 1330 L=2,10
      K=L
      IF(QI(I)-QIQUA(K))1350,1350,1325
 1325 IF(QIQUA(K)-QIQUA(K-1))1345,1345,1330
 1330 CONTINUE
      GO TO 1346
 1345 K = K - 1
 1346 PRINT 1100
 1350 QALI =(QI(I)-QIQUA(K-1))*(QUALI(K)-QUALI(K-1))/(QIQUA(K)-QIQUA(K-1
     1))+QUALI(K-1)
      QUR(I+1)=(QUR(I)*STORA+QI(I)*QALI*CNSTB)/(STORA+QI(I)*CNSTB-EVAPA)
      IF (QULD)1370,1420,1370
 1370 DO 1380 L=2,10
      K=L
      IF(QL(I)-QLQUA(K))1400,1400,1375
 1375 IF(QLQUA(K)-QLQUA(K-1))1395,1395,1380
 1380 CONTINUE
      GO TO 1396
 1395 K = K - 1
 1396 PRINT 1100
 1400 QALL =(QL(I)-QLQUA(K-1))*(QUALL(K)-QUALL(K-1))/(QLQUA(K)-QLQUA(K-1
     1))+QUALL(K-1)
      TEMP=(QL(I)*(QALL-QUALD(I))+EFLNT(I)*371.)/(QUALD(I)-QUR(I))
      TEMP=TEMP/(1.-CLOSS)+ALOS(I)+QOMN2(I)
      IF(QMIN-TEMP)1410,1420,1420
 1410 QMIN = TEMP
      ICSE=7
```

EXHIBIT 4

```
C     ESTIMATED EVAPORATION
 1420 DO 1430 L=2,NSTOR
      K=L
      IF(STRAV-STOR(K))1450,1450,1425
 1425 IF(STOR(K)-STOR(K-1))1440,1440,1430
 1430 CONTINUE
      GO TO 1446
 1440 K = K - 1
 1446 PRINT 1100
 1450 AREAA = (STRAV-STOR(K-1))*(AREA(K)-AREA(K-1))/(STOR(K)-STOR(K-1))+
     1AREA(K-1)
      EVAPA = EVAPO(I)*AREAA*.083333
C              RELEASE TO EMPTY CONSERVATION STORAGE
      QMX = (STORA-STRMN(I)-EVAPA)*CNSTC+QI(I)
C              RELEASE TO FILL CONSERVATION SPACE
      Q=(STORA-STRMX(I)-EVAPA)*CNSTC+QI(I)
      IF(Q-QMAX)1465,1465,1460
 1460 Q=QMAX
      GO TO 1470
 1465 ICASE=11
C              RELEASE TO FILL RESERVOIR
 1470 TMP=(STORA-EVAPA-FULRS)*CNSTC+QI(I)
      IF(Q-TMP)1480,1490,1490
 1480 Q=TMP
      ICASE=8
 1490 IF(Q-QMIN)1500,1510,1510
 1500 Q=QMIN
      ICASE=ICSE
C     COMPUTATION OF INFLOW MINUS EVAPORATION
 1510 TMP=QI(I)-EVAPA*CNSTC
C     PROVISION FOR SHORTAGE IN BOTTOM BUFFER ZONE
      IF (STORA-STRM2(I)) 1610,1660,1660
 1610 IF (STORA-STRMN(I)) 1640,1640,1620
 1620 TEMP = Q-TMP
      IF (TEMP) 1640,1640,1630
C     TENTATIVE STORAGE WITHDRAWAL REDUCED BY BUFFER STORAGE CRITERION
 1630 TMP=TMP+TEMP*(STORA-STRMN(I))/(STRM2(I)-STRMN(I))
 1640 IF(Q-TMP)1660,1660,1650
 1650 Q=TMP
      ICASE=9
 1660 IF(Q-QMX)1680,1680,1670
```

```
 1670 Q=QMX
      ICASE=10
 1680 IF(Q)1690,1700,1700
 1690 Q = 0.
      QPIPE=Q
      QRIVR=Q
 1700 IF(Q-QOMN2(I))1730,1730,1720
 1720 QPIPE=QOMN2(I)
      QRIVR=Q-QOMN2(I)
C     RECOMPUTATION OF POWER AND EVAPORATION USING AVERAGE STAGE
 1730 STRAV = STORA+((QI(I)-Q )*CNSTB-EVAPA)*.5
      IF(NCOMP-NCMP)1740,1750,1750
 1740 NCOMP = NCOMP+1
      GO TO 1050
 1750 DO 1760 L=2,NSTOR
      K=L
      IF(STRAV-STOR(K))1780,1780,1755
 1755 IF(STOR(K)-STOR(K-1))1770,1770,1760
 1760 CONTINUE
      GO TO 1776
 1770 K = K - 1
 1776 PRINT 1100
 1780 AREAA = (STRAV-STOR(K-1))*(AREA(K)-AREA(K-1))/(STOR(K)-STOR(K-1))+
     1AREA(K-1)
      IF(PWR)1790,1860,1790
 1790 TEMP=(-HYDLS)
      IF(HYDLS)1820,1820,1810
 1810 TEMP = HYDLS*QRIVR*QRIVR*.01553
 1820 HEAD = (EL(K)-EL(K-1))*(STRAV-STOR(K-1))/(STOR(K)-STOR(K-1))+EL(K-
     11)-TLWEL-TEMP
      POWER(I) =  QRIVR *HEAD*CPWR
      IF(POWER(I))1830,1840,1840
 1830 POWER(I) = 0.
      GO TO 1850
 1840 IF(POWER(I)-PWRMX*CNST * OVLOD)1860,1860,1850
 1850 POWER(I) = PWRMX*CNST*OVLOD
 1860 EVAPA = EVAPO(I)*AREAA*.083333
C     STORAGE, DOWNSTREAM FLOW, AND SHORTAGES
      STORB(I)=STORA-EVAPA+(QI(I)-Q)*CNSTB
      IF(STORB(I))1870,1900,1900
 1870 Q=Q+STORB(I)*CNSTA
```

EXHIBIT 4

```
      IF(Q)1880,1890,1890
 1880 EVAPA=EVAPA+Q*CNSTB
      Q=0.
 1890 STORB(I)=0.
 1900 QD(I) = (QRIVR-ALOS(I))*(1.-CLOSS)+QL(I)
      IF(QD(I)-QL(I))1910,1920,1920
 1910 QD(I)=QL(I)
 1920 SHRTD(I) = QDMIN(I)+QRT(I)-QD(I)
      IF(SHRTD(I))1930,1940,1940
 1930 SHRTD(I) = 0.
 1940 SHRTP(I) = POWR(I)-POWER(I)
      IF(SHRTP(I))1950,1960,1960
 1950 SHRTP(I)=0.
 1960 SHRTA = QOMN2(I)-QPIPE
      IF(SHRTA)1970,1980,1980
 1970 SHRTA = 0.
 1980 SHRTB=QOMIN(I)-QRIVR
      IF(SHRTB)1990,2000,2000
 1990 SHRTB=0.
C     RESERVOIR AND DOWNSTREAM QUALITY, DOWNSTREAM LOSS
      QULTD(I) = 0.
 2000 IF(QULD)2040,2050,2040
 2040 IF (QD(I))2050,2050,2045
 2045 TEMP = (QRIVR-ALOS(I))*(1.-CLOSS)
      QULTD(I) = (QL(I)*QALL+EFLNT(I)*371.+(TEMP )*QUR(I+1))/QD(I)
 2050 ALSA(I)=ALOS(I)+(Q-ALOS(I))*CLOSS
      IF(ALSA(I)-Q)2070,2070,2060
 2060 ALSA(I)=Q
C     ANNUAL SUMS
 2070 SMBMN=SMBMN+QOMIN(I)*CT
      SMAMN=SMAMN+QOMN2(I)*CT
      SMQMX = SMQMX+QOMAX(I)*CT
      SMDMN=SMDMN+QDMIN(I)*CT
      SMDMX = SMDMX+QDMAX(I)*CT
      SMRTS=SMRTS+QRT(I)*CT
      SMEFT=SMEFT+EFLNT(I)*CT
      IF (QDMN) 2074,2072,2074
 2072 SMQMN = SMQMN+QUALD(I)*CT
      GO TO 2076
 2074 SMQMN=SMQMN+QUALD(I)*QDMIN(I)*CT
 2076 SMPMN=SMPMN+POWR(I)
```

```
      SMEVP = SMEVP+EVAPA
      SMSHA = SMSHA+SHRTA*CT
      SMSHB=SMSHB+SHRTB*CT
      SMI   =SMI+QI(I)*CT
      SML   =SML+QL(I)*CT
      SMQOB=SMQOB+QRIVR*CT
      SMQOA = SMQOA+QPIPE*CT
      SMPWR = SMPWR+POWER(I)
      SMSHP = SMSHP + SHRTP(I)
      SMLOS = SMLOS+ALSA(I)*CT
      SMQD = SMQD+QD(I)*CT
      SMSHD=SMSHD+SHRTD(I)*CT
      SMQAL = SMQAL+QD(I)*QULTD(I)*CT
      IQUR=QUR(I+1)+.5
      PRINT 2080,M(I),QI(I),STRMN(I),STRM2(I),STORB(I),STRMX(I),EVAPA,
     1QOMN2(I),QPIPE,SHRTA,QOMIN(I),QRIVR,SHRTB,QOMAX(I),ICASE,IQUR
 2080 FORMAT(I3,F7.0,4F9.0,F8.0,3F7.0,4F8.0,I4,I5)
 2090 STORA = STORB(I)
      IF (QDMN) 2091,2092,2091
 2091 SMQMN=SMQMN/SMDMN
 2092 IF (SMQD) 2094,2094,2093
 2093 SMQAL = SMQAL/SMQD
 2094 IYR = IYR+1
      QUR(1)=QUR(NPER+1)
C     CYCLE SUMS
      SBMN=SBMN+SMBMN
      SAMN=SAMN+SMAMN
      SQMX = SQMX+SMQMX
      SDMN=SDMN+SMDMN
      SDMX = SDMX+SMDMX
      SRTS=SRTS+SMRTS
      SEFT=SEFT+SMEFT
      SQUMN=SQUMN+SMQMN*SMDMN
      SPMN=SPMN+SMPMN
      SEVP = SEVP+SMEVP
      SSHA = SSHA+SMSHA
      SSHB=SSHB+SMSHB
      SI= SI+SMI
      SL= SL+SML
      SQOB = SQOB+SMQOB
      SQOA=SQOA+SMQOA
```

EXHIBIT 4

```
      SPWR = SPWR+SMPWR
      SSHP=SSHP+SMSHP
      SLOS = SLOS+SMLOS
      SQD = SQD+SMQD
      SSHD=SSHD+SMSHD
      SQAL = SQAL+SMQAL*SMQD
      IF (SMAMN) 2096,2096,2095
 2095 TEMP=SMSHA/SMAMN
      SINDA=SINDA+TEMP*TEMP
 2096 IF (SMBMN) 2098,2098,2097
 2097 TEMP=SMSHB/SMBMN
      SINDB=SINDB+TEMP*TEMP
 2098 IF (SMDMN+SMRTS) 2100,2100,2099
 2099 TEMP=SMSHD/(SMDMN+SMRTS)
      SINDD=SINDD+TEMP*TEMP
 2100 IF(SMPMN) 2102,2102,2101
 2101 TEMP=SMSHP / SMPMN
      SINDP=SINDP+TEMP*TEMP
 2102 PRINT 2105,SMI,SMEVP,SMAMN,SMQOA,SMSHA,SMBMN,SMQOB,SMSHB,SMQMX
 2105 FORMAT(3H YRF7.0,F44.0,3F7.0,4F8.0)
      IF(QDMN+PWR+QDMX+QRTS+QULD)2110,2170,2110
 2110 TEMP=1.
      PRINT 2120
 2120 FORMAT(/11X,16H1000 KW-HR POWER13X,31HCFS AT DOWNSTREAM CONTROL PO
     1INT8X,18HDOWNSTREAM QUALITY)
      PRINT 2130
 2130 FORMAT(96H PER      REQ    ACTUAL    SHRTG  QLOCAL  RIGHTS ADD REQ
     1ACTUAL    SHRTG      MAX   EFLT  REQ ACTUAL)
      DO 2140 I=1, NPER
 2140 PRINT 2150,M(I),POWR(I),POWER(I),SHRTP(I),QL(I),QRT(I),QDMIN(I),QD
     1(I),SHRTD(I),QDMAX(I),EFLNT(I),QUALD(I),QULTD(I)
      PRINT 2160,SMPMN,SMPWR,SMSHP,SML,SMRTS,SMDMN,SMQD,SMSHD,SMDMX,SMEF
     1T,SMQMN,SMQAL
 2150 FORMAT(I3,3F9.0,6F8.0,3F6.0)
 2160 FORMAT(3H YR3F9.0,6F8.0,3F6.0)
      GO TO 2180
 2170 TEMP=0.
 2180 CONTINUE
      SQAL=SQAL/SQD
      SQUMN=SQUMN/SDMN
      SBMN=SBMN*RNYRS
```

```
      SAMN=SAMN*RNYRS
      SQMX = SQMX*RNYRS
      SDMN=SDMN*RNYRS
      SDMX = SDMX*RNYRS
      SRTS=SRTS*RNYRS
      SEFT=SEFT*RNYRS
      SPMN=SPMN*RNYRS
      SEVP=SEVP*RNYRS
      SSHA=SSHA*RNYRS
      SSHB=SSHB*RNYRS
      SI=SI*RNYRS
      SL=SL*RNYRS
      SQOB=SQOB*RNYRS
      SQOA=SQOA*RNYRS
      SPWR=SPWR*RNYRS
      SSHP=SSHP*RNYRS
      SLOS=SLOS*RNYRS
      SQD = SQD*RNYRS
      SSHD=SSHD*RNYRS
      SINDA=SINDA*100.*RNYRS
      SINDB=SINDB*100.*RNYRS
      SINDD=SINDD*100.*RNYRS
      SINDP=SINDP*100.*RNYRS
      PRINT 2190
 2190 FORMAT (//14H GRAND AVERAGE)
      PRINT 980
      PRINT 990
      PRINT 2105,SI,SEVP,SAMN,SQOA,SSHA,SBMN,SQOB,SSHB,SQMX
      IF(TEMP)2210,2210,2200
 2200 PRINT 2120
      PRINT 2130
      PRINT 2160,SPMN,SPWR,SSHP,SL,SRTS,SDMN,SQD,SSHD,SDMX,SEFT,SQUMN,SQ
     1AL
 2210 PRINT 2220,SINDA,SINDB,SINDD,SINDP
 2220 FORMAT (/25H SHORTAGE INDEX, PIPELINEF7.3,8H  OUTLETF7.3,12H  DOWN
     1STREAMF7.3,7H  POWERF7.3//)
      IF(NC-NCYCL)420,10,10
      END
```

EXHIBIT 5

INPUT DATA# - 23-J2-L245

A. Three output title cards - specify adopted flow units

B. Specification Card

1. NYRS - Number of years of routing
2. IYR - Number of first year (such as 1926)
3. NPER - Number of routing periods in year (12 for monthly routing)
4. IPER - Number of first period in each year (10 for October in monthly routing, for example)
5. NDYS - Number of days in each routing period, -1 if to be specified by period
6. NSTOR - Number of points in storage table (up to 40)
7. NCYCL - Number of routings of NYRS (B1) each to be made with same conditions but different flows
8. IACFT - Leave blank if flow requirements are in cfs; positive integer if in acre-feet
9. NCMP - Number of complete computations desired each period for successive approximations of power, evaporation and reservoir quality, usually 2

C-E. General Data Cards

Card C

1. STOR1 - Storage in acre-feet at start of routing
2. CONST - Conversion constant from inflow units to cfs if positive, and to acre-feet, if negative. Leave blank if flows are expressed in cfs, negative if flows are expressed in volume units such as acre-feet, inches or cfs-days, and positive if expressed in rate such as cfs or mgd. (Zero if flows are in cfs, -1.0 if flows are in acre-feet, -1.9835 if in cfs days, and .644 if in mgd)
3. *QOMN - Minimum permissible outflow to river, -1 if to be specified by period once and -2 if to be specified by period every year.

* Units must comply with item B-8.

All data are entered using 8 column fields, 10 per card, except that col. 1 on every card is reserved for identification and not read by computer. Thus only 7 columns are usable in first field of each card.

4. *QMN2 - Minimum permissible outflow to pipeline, -1 if to be specified by period once and -2 if to be specified by period every year
5. QOMX - Maximum permissible release in cfs to river, zero if unlimited, -1 if to be specified by period once and -2 if to be specified by period every year.
6. *QDMN - Minimum permissible flow at downstream control point excluding water rights, -1 if to be specified by period once and -2 if to be specified by period every year
7. QDMX - Maximum permissible flow in cfs at downstream control point, including water rights, zero if unlimited, -1 if to be specified by period once and -2 if to be specified by period every year
8. *QRTS - Water rights at downstream point, -1 if to be specified by period once and -2 if to be specified by period every year. Program will supply rights up to preproject flow.
9. EFLT - Effluent in tons per day between reservoir and downstream point, -1 if to be specified by period once and -2 if to be specified by period every year
10. QULD - Maximum permissible concentration (in parts per million or degrees of temperature) of water quality factor at downstream control point, -1 if to be specified by period once and -2 if to be specified by period every year

Card D

1. QUR(1) - Concentration of water quality factor in reservoir at start of routing, must be positive if any quality routing desired
2. STMX - Maximum permissible conservation storage in acre-feet, -1 if to be specified by period once and -2 if to be specified by period every year
3. STMN - Minimum permissible storage in acre-feet, -1 if to be specified by period once and -2 if to be specified by period every year
4. STMN2 - Storage level equal to or greater than STMN at which shortage is initiated, -1 if to be specified by period once and -2 if to be specified by period every year
5. PWR - Minimum power requirement per period in thousand kw-hr, -1 if to be specified by period once and -2 if to be specified by period every year
6. PWRMX - Installed power capacity in kw
7. EFFCY - Plant efficiency, zero if standard value of .86 to be used, -1 if table with elevation to be supplied

* Units must comply with item B-8.

8. TLWEL - Average tailwater elevation in feet, required only for power
9. QCAP - Outlet capacity in cfs, zero or negative if to be specified by elevation
10. EVAP - Reservoir evaporation (net change to project conditions) in inches for year, -1 if to be specified by period once and -2 if to be specified by period every year

Card E

1. ALOSS - Constant channel loss below reservoir in cfs, -1 if to be specified by period once and -2 if to be specified by period every year
2. CLOSS - Channel loss below reservoir as ratio of flow remaining after any constant loss is subtracted
3. HYDLS - Penstock loss coefficient in $H_{LOSS} = (HYDLS)Q^2/2g$ if positive, penstock loss in feet if negative.
4. FULRS - Reservoir capacity in acre-feet at full pool
5. OVLOD - Maximum permissible power generation rate for period as ratio to installed capacity (normally 1.15)

F-L. Table data cards

F. STOR - Reservoir storage capacities in acre-feet corresponding to areas and elevations given in cards G and H, NSTOR (B6) values, must increase continuously.
G. AREA - Reservoir areas in acres, NSTOR values (B6)
H. EL - Reservoir water surface elevations in feet, NSTOR (B6) values, omit if PWR (D5) is zero.
I. QOCAP - Outlet capacities in cfs, corresponding to storages given in J, up to 10 values, omit if QCAP (D9) is positive.
J. QOSTR - Reservoir storages in acre-feet, up to 10 values, must increase continuously, omit if QCAP (D9) is positive.
K. EFCY - Plant efficiency expressed as a ratio less than 1, corresponding to reservoir elevations (up to 10 values) given in item L, omit if PWR (D5) is zero or EFFCY (D7) is zero or positive.
L. ELEFY - Reservoir elevations in feet, up to 10 values, must increase continuously, omit if PWR (D5) is zero or EFFCY (D7) is zero or positive.

M-P. Water quality tables - Omit if QUR(1) is zero (D1)

M. QUALI - Quality of reservoir inflow (in parts per million or degrees of temperature) corresponding to values in item N, up to 10 values.

N. QIQUA - Reservoir inflow in cfs, up to 10 values, must increase continuously.

O. QUALL - Quality of local inflow corresponding to values in item P, up to 10 values, omit if QULD (C10) is zero.

P. QLQUA - Local inflow in cfs, up to 10 values, must increase continuously, omit if QULD (C10) is zero.

Q-8. Period data cards supplied for first year only for those items whose calling index (see Cards B and C) is -1 and for every year in same relative order for those items whose calling index is -2. - NPER (B3) values for each item

Q. NDAYS - Number of days in each period, omit if NDYS (B5) is positive.

R. *QOMIN - Minimum permissible outflow to river, omit if QOMN (C3) is zero or positive

S. *QOMN2 - Minimum permissible outflow to pipe line, omit if QMN2 (C4) is zero or positive

T. QOMAX - Maximum permissivle release to river in cfs, omit if QOMX (C5) is zero or positive

U. *QDMIN - Minimum permissible flow at downstream control point excluding water rights, omit if QDMN (C6) is zero or positive

V. QDMAX - Maximum permissible flow at downstream control point in cfs, omit if QDMX (C7) is zero or positive

W. *QRITS - Water rights at downstream point, omit if QRTS (C8) is zero or positive

X. EFLNT - Effluent in tons per day, omit if EFLT (C9) is zero or positive, or if QULD (C10) is zero

Y. QUALD - Maximum permissible concentration (in parts per million or degrees of temperature) at downstream control point, omit if QULD (C10) is zero or positive

Z. STRMX - Maximum permissible storage in acre-feet, omit if STMX (D2) is positive

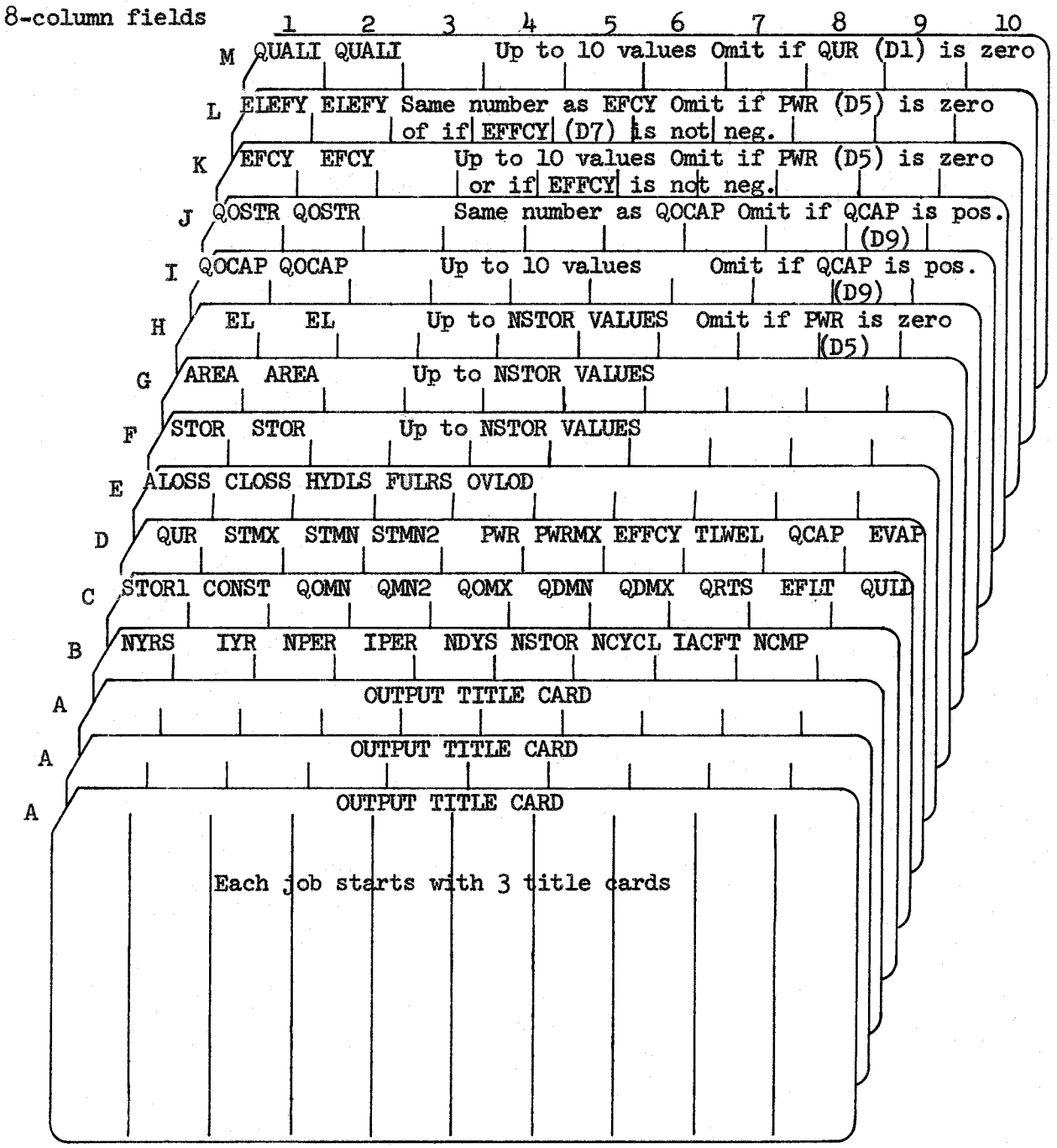
1. STRMN - Minimum permissible storage in acre-feet, omit if STMN (D3) is zero or positive

2. STRM2 - Storage level, equal to or greater than STRMN, at which shortage is initiated, omit if STMN2 (D4) is zero or positive

*Units must comply with item B-8.

3. POWR - Minimum power requirement per period in thousand kw-hr if positive, average load factor if negative, omit if PWR (D5) is zero or positive
4. EVAPO - Reservoir evaporation (net change to project conditions) in inches per period, omit if EVAP (D10) is zero or positive
5. ALOS - Constant channel loss below reservoir in cfs, omit if ALOSS (E1) is zero or positive
6. QI - Reservoir inflow, see item C-2 for units, NPER items (B3) every year
7. QL - Local inflow below reservoir, same units as preceding item, NPER (B3) items every year, omit if QDMN (C6) is zero
8. New cycle start - Required ahead of Item Q for each new cycle (when NCYCL (B7) exceeds 1).
   1. NYRS - Number of years in new cycle
   2. IYR - Number of first year in new cycle (such as 1950)

EXHIBIT 6
23-J2-L245
SUMMARY OF REQUIRED CARDS



NOTE: All data are entered using 8 column fields, 10 per card, except that col. 1 on every card is reserved for identification and not read by computer. Thus only 7 columns are usable in first field of each card.

23-J2-L245
SUMMARY OF REQUIRED CARDS
(Continued)

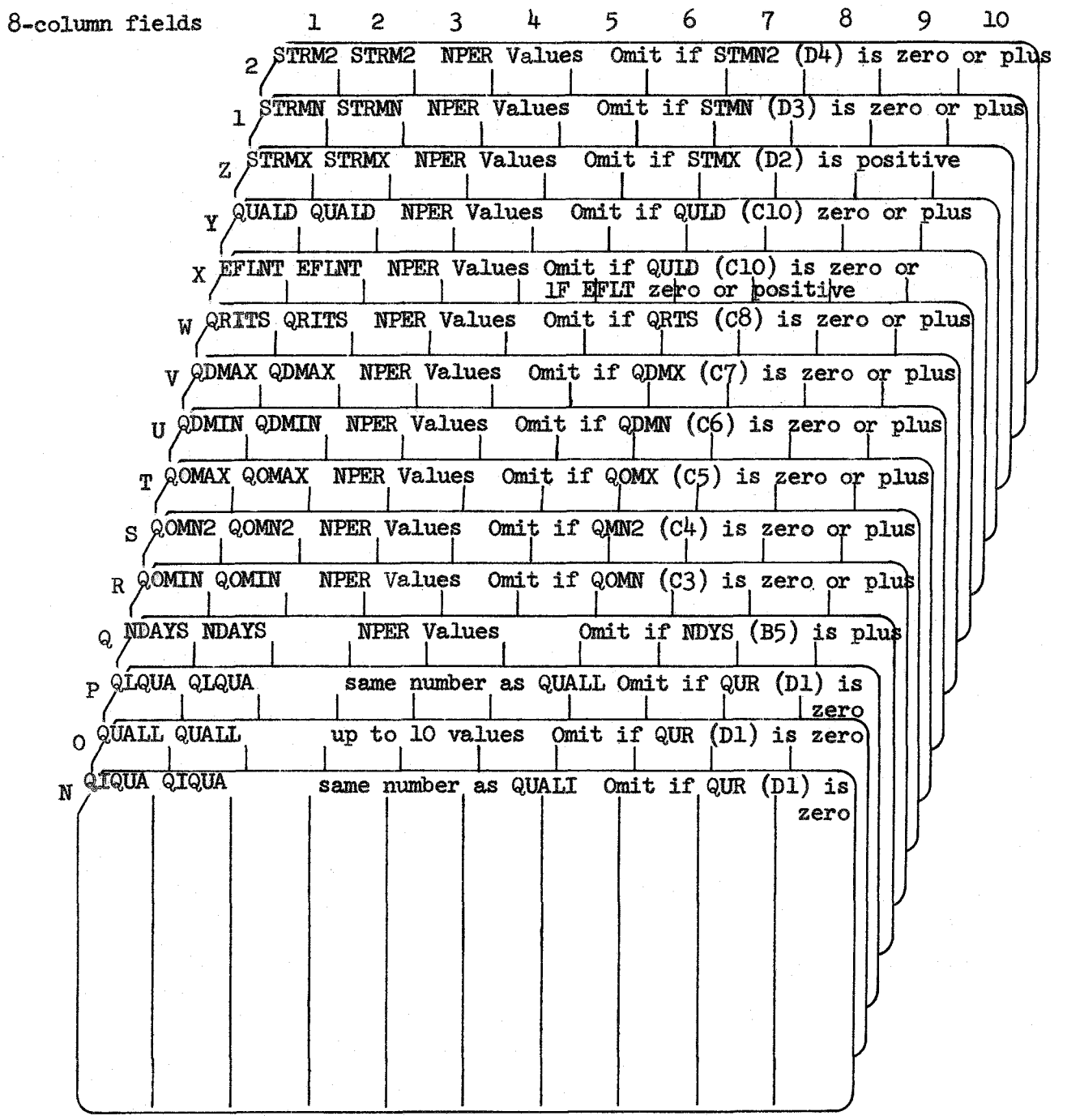
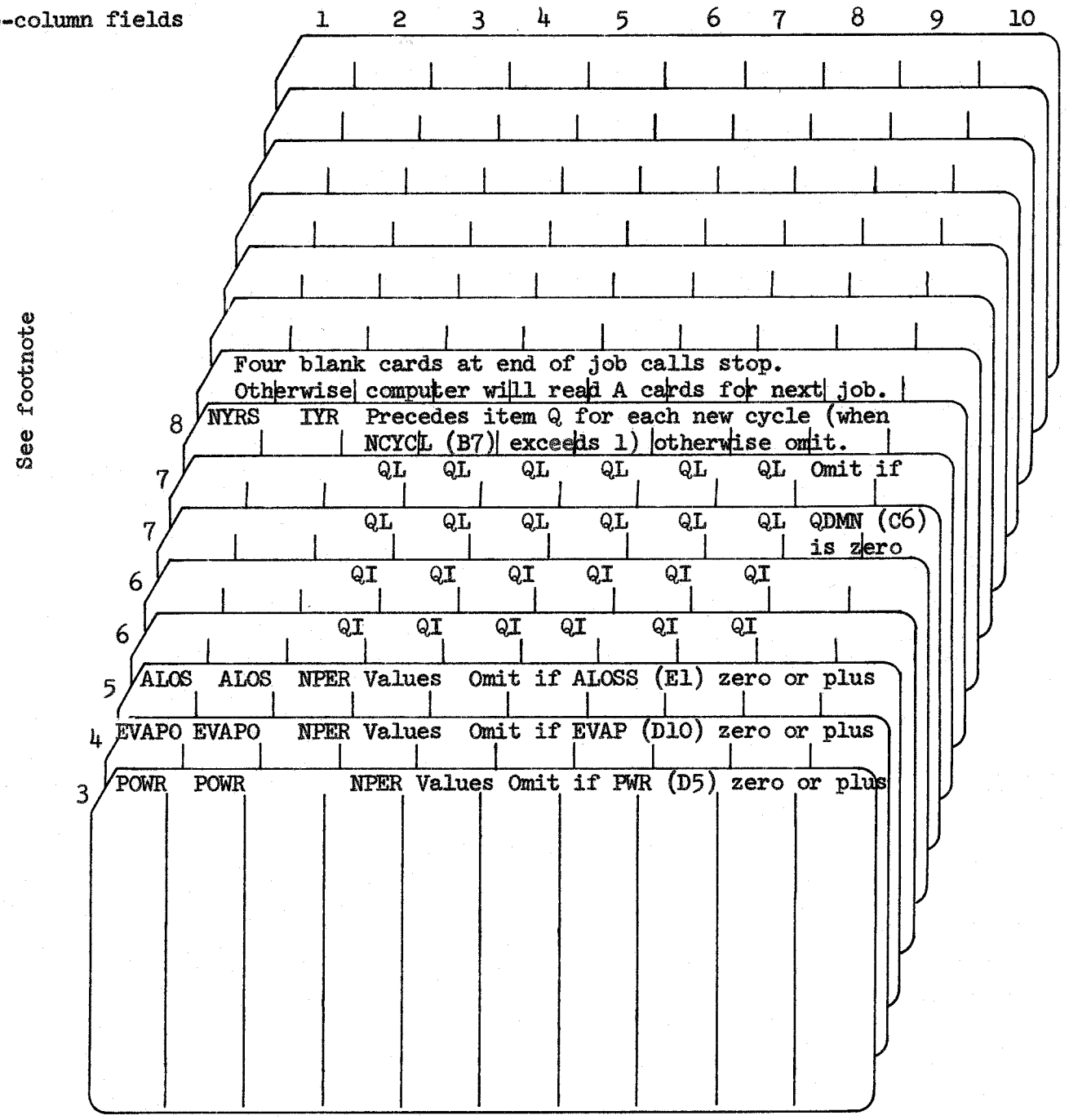


EXHIBIT 6

23-J2-L245
SUMMARY OF REQUIRED CARDS
(Continued)



Note:
Items Q through 7 repeated in same sequence every year.
Except for item 6 required every year, only those items whose calling index is -2 are repeated every year.

EXHIBIT 6