MULTILEVEL COMPUTER MODEL OF WORLD DEVELOPMENT SYSTEM

User Oriented Descriptions

A SERIES: PART VI. MODEL OF GLOBAL WATER CYCLE ON REGIONAL BASIS

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MODEL OF GLOBAL WATER CYCLE ON REGIONAL BASIS

ABSTRACT

The Water Model is intended to provide an estimation of the long range development of global water cycles. The model consists essentially of a demand and supply submodel. The demand part is determined by the economic development, degree of industrialization, type and intensity of agriculture and population level. The supply side is represented in terms of surface water, ocean and sea water, ground water and the water in the atmosphere.

By specifying appropriate scenaria the user of the model can investigate the effects of different growth rates for population and economic growth on the regional water cycle. In order to account for the great importance of cooling water for thermo-electrical power generation, installed power capacity is treated as a scenario variable in the model.

It should be pointed out that the model in it's present state is a water quantity model, and does not explicitly deal with the water quality.

For a detailed report on the model see [6].

I. MATHEMATICS OF THE WATER MODEL

The Water Model uses an extensive list of variables and parameters which is given below:

A. Notation

ISTAT	:	Initial year for model computations (= 1975)
MAXIYR	:	Last year to be considered (= 2025)
GRP	:	Gross regional product
GRPR	:	Growth rate of gross regional product
WI	:	Industrial water demand
GRWI	:	Increment of industrial water demand
WIK	:	Coefficient relating industrial water demand to GRP
IPK	:	Industrial production, coefficient
WIL	:	Industrial water demand of land surface water
WILK	:	Industrial water demand of land water, coefficient
WIO	:	Industrial water demand of ocean water

WIOK : Industrial water demand of ocean water, coefficient
WIG : Industrial water demand of ground water
WIGK : Industrial water demand of ground water, coefficient
WIW : Industrial waste water
WIWK : Industrial waste water, coefficient
WIRC : Water for industry recycled
WIRCK : Water for industry recycled, coefficient
WIR : Water that is returned from industrial sector
WIRK : Industrial water returned, coefficient
WIRL : Water returned from industrial sector to land
WIRLK : Water returned from industrial sector to land, coefficient
WIRO : Water returned from industrial sector to ocean water
WIROK : Water returned from industrial sector to ocean water, coefficient
WIRG : Water returned from industrial sector to ground water
WIRGK : Water returned from industrial sector to ground water, coefficient
POP : Population number
POPR : Population growth rate
WD : Domestic water demand
GRWD : Increment of domestic water demand
WDG : Domestic water demand of ground water
WDGK : Domestic water demand of ground water, coefficient
WDL : Domestic water demand of land surface water
WDLK : Domestic water demand of land surface water, coefficient
WDO : Domestic water demand of ocean water
WDOK : Domestic water demand of ocean water, coefficient
WDW : Waste water from domestic use
WDWK : Waste water from domestic use, coefficient
WDR : Domestic waste water that is returned

WDRK : Domestic waste water that is returned, coefficient
WDRG : Domestic waste water returned to ground
WDRGK : Domestic waste water returned to ground, coefficient
WDRL : Domestic waste water returned to land
WDRLK : Domestic waste water returned to land, coefficient
WDRO : Domestic waste water returned to ocean
WDROK : Domestic waste water returned to ocean, coefficient
AL : Arable land
ALDR : Growth rate of arable land
WA : Agricultural water demand
GRWA : Increment of agricultural water demand
WAW : Waste water from agricultural use
WAWK : Waste water from agricultural use, coefficient
WAR : Agricultural waste water returned
WARK : Agricultural waste water returned, coefficient
WAG : Agricultural water demand of ground water
WAGK : Agricultural water demand of ground water, coefficient
WAL : Agricultural water demand of land surface water
WALK : Agricultural water demand of land surface water, coefficient
WAO : Agricultural water demand of ocean water
WAOK : Agricultural water demand of ocean water, coefficient
WARG : Agricultural waste water returned to ground
WARGK : Agricultural waste water returned to ground, coefficient
WARL : Agricultural waste water returned to land
WARLK : Agricultural waste water returned to land, coefficient
WARO : Agricultural waste water returned to ocean
WAROK : Agricultural waste water returned to ocean, coefficient

WIC : Cooling water demand
GRWIC : Increment of cooling water demand
WICK : Coefficient relating cooling water demand to GRP
WICL : Cooling water demand of land surface water
WICLK : Cooling water demand of land surface water, coefficient
WICO : Cooling water demand of ocean water
WICOK : Cooling water demand of ocean water, coefficient
WICG : Cooling water demand of ground water
WICGK : Cooling water demand of ground water, coefficient
WICW : Waste water from cooling processes
WICWK : Waste water from cooling processes, coefficient
WICR : Cooling water returned
WICRK : Cooling water returned, coefficient
WICRL : Cooling water returned to land surface water
WICRLK : Cooling water returned to land surface water, coefficient
RL : Rain on land
RLC : Rain on land, cultural, rate
RLN : Rain on land, natural
RO : Rain on ocean
ROC : Rain on ocean, cultural, rate
RON : Rain on ocean, natural
SL : Snow on land
SLC : Snow on land, cultural, rate
SLN : Snow on land, natural
SO : Snow on ocean
SOC : Snow on ocean, cultural, rate
SON : Snow on ocean, natural
WLA : Water from land surface to atmosphere
WLASK : Water from land to atmosphere per unit surface, coefficient
WOA : Water from ocean to atmosphere
WOASK : Water from ocean to atmosphere per unit surface, coefficient
TSL : Total snow on land
SMK : Snow melting, coefficient
WSL : Water from snow melting

LS	:	Land surface
OS	:	Ocean surface
TWS	:	Ocean water due to desalting
TWSI	:	Ocean water due to desalting , initial value
GIWL	:	Increment of water due to land management
GIWS	:	Increment of water due to desalting
GIWO	:	Increment of ocean water used
XWLM	:	Water due to land management
TWSWL	:	Ocean water used (without desalting)
WICG	:	Cooling water demand of ground water
WICGK	:	Cooling water demand of ground water, coefficient
WGL	:	Water that goes from ground water to land surface water
WGLK	:	Water that goes from ground water to land surface water, coefficient
WLG	:	Water that goes from land surface to ground water
WLGK	:	Water that goes from land surface to ground water, coefficient
TWG	:	Total ground water
WLO	:	Water that goes from land surface to ocean water
WLOK	:	Water that goes from land surface to ocean water, coefficient
TWL	:	Total land surface water
TWIM	:	Total water impounded
TWIMK	:	Total water impounded, coefficient
WLIP	:	Water from land for industry, planned
WLIPK	:	Water from land for industry, coefficient
WOIP	:	Water from ocean for industry, planned
WOIPK	:	Water from ocean for industry, coefficient
WGIP	:	Ground water to industry, planned
WGIPK	:	Ground water to industry, coefficient
WOSIP	:	Ocean water to industry due to desalting
WOSIK	:	Ocean water to industry due to desalting, coefficient
WLMIP	:	Water to industry due to land management
WLMIK	:	Water to industry due to land management, coefficient

WIP : Total water for industry, planned
WLDP : Land surface water for domestic use, planned
WLDPK : Land surface water for domestic use, coefficient
WODP : Ocean water for domestic use, planned
WODPK : Ocean water for domestic use, coefficient
WGDP : Ground water for domestic use, planned
WGDPK : Ground water for domestic use, coefficient
WOSDP : Domestic water due to desalting, planned
WOSDK : Domestic water due to desalting, coefficient
WLMDP : Domestic water due to land management, planned
WLMDK : Domestic water due to land management, coefficient
WDP : Total water for domestic use, planned
WLAP : Land surface water for agriculture, planned
WLAPK : Land surface water for agriculture, coefficient
WOAP : Ocean water for agriculture, planned
WOAPK : Ocean water for agriculture, coefficient
WGAP : Ground water for agriculture, planned
WGAPK : Ground water for agriculture, coefficient
WOSAP : Agricultural water due to desalting, planned
WOSAK : Agricultural water due to desalting, coefficient
WLMAP : Agricultural water due to land management, planned
WLMAK : Agricultural water due to land management, coefficient
WAP : Total water for agriculture, planned
WLICP : Cooling water from land surface water, planned
WLICPK : Cooling water from land surface water, coefficient
WOICP : Cooling water from ocean water, planned
WOICPK : Cooling water from ocean water, coefficient
WGICP : Cooling water from ground water, planned
WGICPK : Cooling water from ground water, coefficient
WOSICP : Cooling water due to desalting, planned
WOSICK : Cooling water due to desalting, coefficient
WLMICP : Cooling water due to land management, planned
WLMICK : Cooling water due to land management, coefficient
WICP : Total cooling water, planned
SWI : Difference between industrial water supply and demand

SWD : Difference between doemstic water supply and demand

SWA : Difference between agricultural water supply and demand

SWIC : Difference between cooling water supply and demand

ENH : Non-hydro power capacity

TINH : Increment of installed non-hydro-electric power capacity

EH : Installed hydro-electric power capacity

TIEH : Increment of installed hydro-electric power capacity

SE : Difference between energy supply and demand

EC : Energy consumption per capita

EK : Ratio of effective to installed hydro capacity

PIND1 : Ratio of FACT to total land surface water

PIND2 : Ratio of FACT to total ground water

FACT : Accumulative sum of industrial, agricultural and domestic water demand

ISWC1 : Control parameter

B. Model Equations

Using the above notation the model equations are as follows:

B.1 Water Demand

$$GRP_{t+1} = GRP_t \cdot (1 + GRPR)$$

$$WI_{t+1} = \begin{cases} WI_t + GRWI_t & \text{for ISWC1} = 1 \\ WIK \cdot IPK \cdot GRP_{t+1} & \text{for ISWC1} \neq 1 \end{cases}$$

$$WIL_t = WILK \cdot WI_t$$

$$WIO_t = WIOK \cdot WI_t$$

$$WIG_t = WIGK \cdot WI_t$$

$$WIW_t = WIWK \cdot WI_t$$

$$WIRC_t = WIRCK \cdot WIW_t$$

$$WIR_t = WIRK \cdot WIW_t$$

$$WIRL_t = WIRLK \cdot WIR_t$$

$$WIRO_t = WIROK \cdot WIR_t$$

$$WIRG_t = WIRGK \cdot WIR_t$$

$$POP_{t+1} = POP_t \cdot (1 + POPR)$$

$$WD_{t+1} = \begin{cases} WD_t + GRWD_t & \text{for ISWC1} = 1 \\ WD_t \cdot (1 + POPR) & \text{for ISWC1} \neq 1 \end{cases}$$

$$WDG_t = WDGK \cdot WD_t$$

$$WDL_t = WDLK \cdot WD_t$$

$$WDO_t = WDOK \cdot WD_t$$

$$WDW_t = WDWK \cdot WD_t$$

$$WDR_t = WDRK \cdot WDW_t$$

$$WDRG_t = WDRGK \cdot WDR_t$$

$$WDRL_t = WDRLK \cdot WDR_t$$

$$WDRO_t = WDROK \cdot WDR_t$$

$$WA_{t+1} = \begin{cases} WA_t + GRWA_t & \text{for ISWC1} = 1 \\ WA_t \cdot (1 + ALDR) & \text{for ISWC1} \neq 1 \end{cases}$$

$$WAW_t = WAWK \cdot WA_t$$

$$WAR_t = WARK \cdot WAW_t$$

$$WAG_t = WAGK \cdot WA_t$$

$$WAL_t = WALK \cdot WA_t$$

$$WAO_t = WAOK \cdot WA_t$$

$$AL_{t+1} = AL_t \cdot (1 + ALDR)$$

$$WARG_t = WARGK \cdot WAR_t$$

$$WARL_t = WARLK \cdot WAR_t$$

$$WARO_t = WAROK \cdot WAR_t$$

$$WIC_{t+1} = \begin{cases} WIC_t + GRWIC_t & \text{for ISWC1} = 1 \\ WICK \cdot GRP_{t+1} & \text{for ISWC1} \neq 1 \end{cases}$$

$$WICL_t = WICLK \cdot WIC_t$$

$$WICO_t = WICOK \cdot WIC_t$$

$$WICG_t = WICGK \cdot WIC_t$$

$$WICW_t = WICWK \cdot WIC_t$$

$$WICRL_t = WICRLK \cdot WIC_t$$

$$WICR = WICRK \cdot WIC_t$$

B.2 Water Resources

$$RL = (1 + RLC) \cdot RLN$$

$$RO = (1 + ROC) \cdot RON$$

$$SL = (1 + SLC) \cdot SLN$$

$$SO = (1 + SOC) \cdot SON$$

$$WLA = WLASK \cdot LS$$

$$WOA = WOASK \cdot OS$$

$$TSL = (1 - SMK) \cdot SL$$

$$WSL = SMK \cdot TSL$$

$$XWLM_{t+1} = XWLM_t + GIWL_t$$

$$TWS_{t+1} = TWS_t + GIWS_t$$

$$TWSWL_{t+1} = TWSWL_t + GIWO_t$$

$$WGL_t = WGLK \cdot TWG_t$$

$$WLG_t = WLGK \cdot TWL_t$$

$$TWG_{t+1} = TWG_t + WLG_t - WGL_t - WIG_t + WIRG_t - WDG_t + WDRG_t - WAG_t + WARG_t - WICG_t$$

$$WLO_t = WLOK \cdot TWL_t$$

$$TWL_{t+1} = TWL_t + WGL_t - WLG_t - WIL_t + WIRL_t - WDL_t + WDRL_t - WAL_t + WARL_t + RL + TSL_t - WLO_t - WLA_t$$

$$TWIM_t = TWIMK \cdot TWL_t$$

B.3 Water Supply

$$WLIP_t = WLIPK \cdot TWL_t$$

$$WOIP_t = WOIPK \cdot TWSWL_t$$

$$WGIP_t = WGIPK \cdot TWG_t$$

$$WOSIP_t = WOSIK \cdot TWS_t$$

$$WLMIP_t = WLMIK \cdot XWLM_t$$

$$WIP_t = WLIP_t + WOIP_t + WGIP_t + WOSIP_t + WLMIP_t$$

$$WLDP_t = WLDPK \cdot TWL_t$$

$$WODP_t = WODPK \cdot TWSWL_t$$

$$WGDP_t = WGDPK \cdot TWG_t$$

$$WOSDP_t = WOSDK \cdot TWS_t$$

$$WLMDP_t = WLMDK \cdot XWLM_t$$

$$WDP_t = WLDP_t + WODP_t + WGDP_t + WOSDP_t + WLMDP_t$$

$$WLAP_t = WLAPK \cdot TWL_t$$

$$WOAP_t = WOAPK \cdot TWSWL_t$$

$$WGAP_t = WGAPK \cdot TWG_t$$

$$WOSAP_t = WOSAK \cdot TWS_t$$

$$WLMAP_t = WLMAK \cdot XWLM_t$$

$$WAP_t = WLAP_t + WOAP_t + WGAP_t + WOSAP_t + WLMAP_t$$

$$WLICP_t = WLICPK \cdot TWL_t$$

$$WOICP_t = WOICPK \cdot TWSWL_t$$

$$WGICP_t = WGICPK \cdot TWG_t$$

$$WOSICP_t = WOSICK \cdot TWS_t$$

$$WLMICP_t = WLMICK \cdot XWLM_t$$

$$WICP_t = WLICP_t + WOICP_t + WOSICP_t + WLMICP_t + WGICP_t$$

B.4 Criteria

$$SWI_t = WIP_t - WI_t$$

$$SWD_t = WDP_t - WD_t$$

$$SWA_t = WAP_t - WA_t$$

$$SWIC_t = WICP_t - WIC_t$$

$$ENH_{t+1} = ENH_t + TINH_t \cdot 1000.0$$

$$EH_{t+1} = EH_t + TIEH_t \cdot 1000.0$$

$$SE_t = - EC \cdot POP_t + (ENH_t + EK \cdot EH_t)$$

$$FACT_t = WI_t + WD_t + WA_t$$

$$PIND1_t = FACT_t/TWL_t$$

$$PIND2_t = FACT_t/TWG_t$$

II. TERMINAL INPUT AND DATA BASE

A. Requests from the Model

In order to run the model you have to specify the region and the scenario number for which you want the model to produce a run. For this purpose the model will issue some appropriate requests (this will only occur under DOS):

"ENTER REGION, E.G. 06"

At this request you may specify the region you are interested in (format (I2)).

"SCENARIO NUMBER, E.G. 03"

At this request the model asks for a scenario number. There are a few scenaria already prepared. If you want to specify your own values for the various parameters then type "99" and your scenario will be read from the card reader (device number 3).

"SCENARIO NUMBER NON-EXISTENT--TRY AGAIN"

This message will appear if you have specified a scenario number that was either too large or less than 1. At this point you will be asked again for a scenario number.

B. Scenario Preparation

There are 53 scenario variables to be specified when preparing a scenario, and they fit on 10 punched cards.

CARD NUMBER 1

NMAX : Under DOS the first record shows the number of available scenaria

ISCEN : Under UNIX and CYBER the first card takes the scenario number.

CARD NUMBER 2

GRWD : Annual increment of domestic water demand (10^9 cubic meters)

GRWI : Annual increment of industrial water demand (10^9 cubic meters)

GRWIC : Annual increment of industrial cooling water demand (10^9 cubic meters)

GRWA : Annual increment of agricultural water demand (10^9 cubic meters)

WLMIK : Water to industry from land management, coefficient

WLMDK : Water to domestic use from land management, coefficient

WLMAK : Water to agriculture from land management, coefficient

WLMICK : Cooling water from land management, coefficient

CARD NUMBER 3

WOSIK : Desalted ocean water to industry, coefficient

WOSDK : Desalted ocean water to domestic use, coefficient

WOSAK : Desalted ocean water to agriculture, coefficient

WOSICK : Cooling water due to desalting, coefficient

WOICPK : Cooling water from ocean, planned, coefficient

CARD NUMBER 4

WGAPK : Water from ground to agriculture, planned, coefficient

WGDPK : Water from ground to domestic use, planned, coefficient

WGIPK : Water from ground to industry, planned coefficient

WGICPK : Cooling water from ground, planned, coefficient

WLAPK : Water from land to agriculture, planned, coefficient

WLDPK : Water from land to domestic use, planned, coefficient

WLIPK : Water from land to industry, planned, coefficient

WLICPK : Cooling water from land, planned, coefficient

CARD NUMBER 5

GIWLA(I), I = 1,6 : Time-series for increments of water due to land management. Units are 10^9 cubic meters. Data points are 1975, 1985, 1995, 2005, 2015, 2025.

CARD NUMBER 6

GIWSA(I), I = 1,6 : Time-series for increments of water due to desalting of ocean water. Units are 10^9 cubic meters. Data points are 1975, 1985, 1995, 2005, 2015, 2025.

CARD NUMBER 7

GIWOA(I), I = 1,6 : Time-series for increments of ocean water used (without desalting) Units are 10^9 cubic meters. Data points are 1975, 1985, 1995, 2005, 2015, 2025.

CARD NUMBER 8

TINH(I), I = 1,6 : Time-series for increments in installed non-hydro-electric power capacity. Units are 10^3 MW. Data points as for GIWLA.

CARD NUMBER 9

TIEH(I), I = 1,6 : Time-series for increments in installed hydro-electric power capacity. Units are 10^3 MW. Data points are the same as for GIWLA. The above described 8 punched cards are read with format (3X,8E9.4).

CARD NUMBER 10

ISCW1 : This is a control parameter, which should be set either equal to 1 or 0. If ISWC1 is equal to 1 the annual increments of WA,WI,WD and WIC are

assumed to have the values of GRWA, GRWI, GRWD, GRWIC respectively. For ISWC1 equal to 0 the annual increments are calculated using the growth rate of gross regional product, and population growth respectively. ISWC1 is read with format (8X, 12).

Scenario data are read from device number 2. Under DOS device number 3 is used to read in "99" scenaria.

C. Data Base

For each region the model needs a basic set of data that fits on 12 punched cards by format (8X, 8E9.4). Units are 10^9 M^3 unless there is a unit given in brackets.

CARD NUMBER 1

NAME(J), J = 1,12 : Region label with up to 24 characters (read with format (12A2))

CARD NUMBER 2

POP(1) : Population number (initial value for 1975 in individuals)

GRP(1) : Gross regional output (initial value for 1975 in 10^9 US $)

WIW : Industrial water wasted (initial value for 1975)

WIRC : Cooling water returned (initial value for 1975)

WD(1) : Domestic water demand (initial value for 1975)

WA(1) : Agricultural water demand (initial value for 1975)

AL : Arable land (initial value for 1975 in square kilometers)

TSL(1) : Total snow on land (initial value for 1975)

CARD NUMBER 3

TWG(1) : Total water ground (initial value for 1975)

TWL(1) : Total water land (initial value for 1975)

TWSWL(1) : Ocean water used (initial value for 1975)

TWSI : Ocean water due to desalting (initial value for 1975)

WIC(1) : Cooling water demand (initial value for 1975)

XWLM(1) : Total water due to land management (initial value for 1975)

WI(1) : Industrial water demand (initial value for 1975)

CARD NUMBER 4

GRPR : Growth rate of gross regional product

WIK : Industrial water, coefficient (in $KM^3/10^9$ US $)

IPK : Industrial production, coefficient

WIWK : Industrial waste water, coefficient

WILK : Industrial water from land, coefficient

WIOK : Industrial water from ocean, coefficient

WIGK : Industrial water from ground, coefficient

CARD NUMBER 5

WIRK : Industrial water returned, coefficient

WIRLK : Industrial water returned to land, coefficient

WIROK : Industrial water returned to ocean, coefficient

WIRGK : Industrial water returned to ground, coefficient

POPR : Population growth rate

WDK : Domestic water, coefficient (in KM^3/year/capita)

WDGK : Domestic water from ground, coefficient

WDLK : Domestic water from land, coefficient

CARD NUMBER 6

WDOK : Domestic water from ocean, coefficient

WDWK : Domestic waste water, coefficient

WDRK : Domestic water returned, coefficient

WDRGK : Domestic water returned to ground, coefficient

WDRLK : Domestic water returned to land, coefficient
WDROK : Domestic water returned to ocean, coefficient
WAGK : Agricultural water from ground, coefficient

CARD NUMBER 7

WALK : Agricultural water from land, coefficient
WAOK : Agricultural water from ocean, coefficient
WAWK : Agricultural water wasted, coefficient
WARK : Agricultural water returned, coefficient
WARGK : Agricultural water returned to ground, coefficient
WARLK : Agricultural water returned to land, coefficient
WAROK : Agricultural water returned to ocean, coefficient
RLC : Rain on land, cultural, coefficient

CARD NUMBER 8

RLN : Rain on land, natural (initial value for 1975)
ROC : Rain on oceans, cultural, coefficient
RON : Rain on oceans, natural (initial value for 1975)
SLC : Snow on land, cultural, coefficient
SLN : Snow on land, natural (initial value for 1975)
SOC : Snow on ocean, cultural, coefficient
SON : Snow on ocean, natural (initial value for 1975)
SMK : Snow melting, coefficient

CARD NUMBER 9

LS : Land surface (in KM^2)
WLASK : Water from land to atmosphere per unit surface, coefficient
OS : Ocean surface (in KM^2)
WOASK : Water from ocean to atmosphere per unit surface, coefficient
WGLK : Water from ground to land, coefficient

CARD NUMBER 10

WLGK : Water from land to ground, coefficient
WLOK : Water from land to ocean, coefficient
TWIMK : Impounded water, coefficient
WOIPK : Water from ocean for industry, planned, coefficient
WODPK : Water from ocean for domestic, planned, coefficient
WOAPK : Water from ocean to agriculture, planned, coefficient

CARD NUMBER 11

WIRCK : Industrial water recycled, coefficient
WDRCK : Domestic water recycled, coefficient
EC : Energy per capita (in MW)
ENH : Non-hydro power capacity (initial value for 1975 in MW)
EH : Installed hydro-electric power capacity (initial value for 1975 in MW)
EK : Ratio of effective to installed hydro capacity
WICK : Cooling water, coefficient (in $KM^3/10^6$ US $)

CARD NUMBER 12

WICLK : Cooling water from land, coefficient
WICOK : Cooling water from ocean, coefficient
WICGK : Cooling water from ground, coefficient
WICWK : Waste water from cooling, coefficient
WICRLK : Cooling water returned to land, coefficient
WICRK : Cooling water recycled, coefficient
ALDR : Ratio of agricultural land development.

All these data are read from device number 1.

III. OUTPUT

The output of the Water Model consists of some 37 pages. The first page is a reproduction of the input scenario. The other pages show either time-series of some of the variables used in the model (from 1975 to 2025 by one year increments),

or they give plots of the relevant variables. Units are usually 10^9 cubic meters. For variables that take a different unit, this will be mentioned when describing the variable.

PAGE 1: Region and scenario label as well as reproduction of the input scenario as described in the previous section.

PAGE 2: Time-series of the following variables are listed:

GRP : Gross regional product (units are billions of US $)
WI : Industrial water demand
WIL : Industrial water to be taken from land surface water
WIG : Industrial water to be taken from ground water
WIO : Industrial water to be taken from ocean water.

PAGE 3: Plots of GRP, WI, WIL, WIG and WIO. The head of each plot shows the variables that are plotted, the number by which they are represented on the plotting, and the scaling factor that has been used.

PAGE 4: Time-series of the following variables are listed:

WIW : Waste water from industrial sector
WIR : Water that is returned from industrial sector
WIRL : Water returned from industrial sector to land
WIRO : Water returned from industrial sector to ocean water
WIRG : Water returned from industrial sector to ground water
WIRC : Cooling water returned.

PAGE 5: Plots of WIW, WIR, WIRL, WIRO and WIRG are given.

PAGE 6: Time-series of the following variables are listed:

POP : Population number of region (individuals)
WD : Domestic water demand

WDG : Domestic water demand to be taken from ground water

WDL : Domestic water demand to be taken from land surface water

WDO : Domestic water demand to be taken from ocean water.

PAGE 7: Plots of POP, WD, WDG, WDL and WDO.

PAGE 8: Time-series of the following variables are listed:

WDW : Waste water from domestic use

WDR : Domestic waste water returned

WDRG : Domestic waste water returned to ground water

WDRL : Domestic waste water returned to surface water

WDRO : Domestic waste water returned to ocean water.

PAGE 9: Plots of WDW, WDR, WDRG, WDRL and WDRO.

PAGE 10: Time-series of the following variables are listed:

AL : Arable land (in square kilometers)

WA : Agricultural water demand

WAG : Agricultural water demand to be taken from ground water

WAL : Agricultural water demand to be taken from land surface water

WAO : Agricultural water demand to be taken from ocean water.

PAGE 11: Plots of AL, WA, WAG, WAL and WAO.

PAGE 12: Time-series of the following variables are listed:

WAW : Waste water from agricultural use

WAR : Agricultural water returned

WARG : Agricultural water that is returned to ground water

WARL : Agricultural water that is returned to land surface water

WARO : Agricultural water that is returned to ocean water.

PAGE 13: Plots of WAW, WAR, WARG, WARL and WARO

PAGE 14: Time-series of the following variables are listed:

WIC : Cooling water demand used for electrical power generation

WICL : Cooling water demand to be taken from land surface water

WICG : Cooling water demand to be taken from ground water

WICO : Cooling water demand to be taken from ocean water.

PAGE 15: Plots of WIC, WICL, WICG and WICO

PAGE 16: Time-series of the following variables are listed:

WICW : Waste water from cooling processes

WICR : Cooling water returned

WICRL : Cooling water returned to land surface water.

PAGE 17: Plots of WICW, WICR and WICRL.

PAGE 18: Time-series of the following variables are listed:

TWG : Total ground water

WGL : Water that goes from ground water to land surface water

TWLM : Increase in surface water supplies due to land management

WLO : Water that goes from land surface water to ocean water

WLG : Water that goes from land surface water to ground water.

PAGE 19: Plots of TWG, WGL, TWLM, WLO and WLG.

PAGE 20: Time-series of the following variables are listed:

TWL : Total land surface water

TWIM : Total water impounded.

PAGE 21: Plots of TWL and TWIM.

PAGE 22: Time-series of the following variables are listed:

WLIP : Water from land to industry, planned

WOIP : Water from ocean for industry, planned

WGIP : Ground water to industry, planned

WOSIP : Ocean water to industry due to desalting, planned

WLMIP : Land surface water to industry due to land management.

PAGE 23: Plots of WLIP, WOIP, WGIP, WOSIP and WLMIP.

PAGE 24: Time-series of the following variables are listed:

WLDP : Land surface water for domestic use, planned

WODP : Ocean water for domestic use, planned

WGDP : Ground water for domestic use, planned

WOSDP : Desalted ocean water for domestic use, planned

WLMDP : Land surface water to domestic use due to land management, planned.

PAGE 25: Plots of WLDP, WODP, WGDP, WOSDP and WLMDP.

PAGE 26: Time-series of the following variables are listed:

WLAP : Land surface water to agriculture, planned

WOAP : Ocean water to agriculture, planned

WGAP : Ground water to agriculture, planned

WOSAP : Desalted ocean water to agriculture, planned

WLMAP : Land surface water to agriculture due to land management, planned.

PAGE 27: Plots of WLAP, WOAP, WGAP, WOSAP, WLMAP.

PAGE 28: Time-series of the following variables are listed:

WLICP : Cooling water from land surface water, planned
WOICP : Cooling water from ocean water, planned
WGICP : Cooling water from ground water, planned
WOSICP : Cooling water from desalted ocean water, planned
WLMICP : Cooling water from land surface water due to land management, planned

PAGE 29: Plots of WLICP, WOICP, WGICP, WOSICP and WLMICP.

PAGE 30: Time series of the following variables are listed:

WIP : Accumulative amount of water planned for industry
WDP : Accumulative amount of water planned for domestic use
WAP : Accumulative amount of water planned for agriculture
WICP : Accumulative amount of water planned for cooling water use.

PAGE 31: Plots of WIP, WDP, WAP and WICP.

PAGE 32: Time-series of the following variables are listed:

SWI : Difference between industrial water supply and industrial water demand
SWD : Difference between domestic water supply and domestic water demand
SWA : Difference between agricultural water supply and agricultural water demand
SWIC : Difference between cooling water supply and cooling water demand.

PAGE 33: Plots of SWI, SWD, SWA and SWIC

PAGE 34: Time-series of the following variables are listed:

TWS : Total water due to desalting

ENH : Installed non-hydro power capacity (in megawatts)

EH : Installed hydro-electric power capacity (in megawatts)

SE : Difference between energy supply and energy demand (in megawatts).

PAGE 35: Plots of TWS, ENH, EH and SE.

PAGE 36: Time-series of the following variables are listed:

FACT : Accumulative sum of industrial, agricultural and domestic water demand

PIND1 : Ratio of FACT to total land surface water

PIND2 : Ratio of FACT to total ground water.

PAGE 37: Plots of FACT, PIND1, PIND2.

```
99
USA 99  1.3915    4.554     2.4145E+1.9185     .8662 E+2.129      .075
USA 99  .349      .447      .400      .600      .000      .000
USA 99  3.136 E-46.41  E-56.26  E-52.97  E-52.875 E-36.37  E-41.312 E-35.504 E-3
USA 99  5.0       5.0       5.0       5.0       5.0       5.0
USA 99  .003      .03       .06       .09       .09       .11
USA 99  0.0       0.0       0.0       0.0       0.0       0.0
USA 99  21.2      31.4      61.5      120.5     236.2     463.0
USA 99  3.9       5.7       11.0      22.2      44.0      85.0
USA 99  00
```

UNITED STATES

USA	.224	E+9.103	E+4.578	E+2.226	E+3.386	E+2.179	E+3.936	E+64.65	E+2
USA	.198	E+6.400	E+51.43	E+7.076	.226	E+3.000	.6500	E+2	
USA	.034	.0632	1.00	.890	.808	2.63	E-4.191		
USA	.700	.850	.100	.050	.011	.172	E-6.340	.660	
USA	7.87	E-05.760	.400	.050	.800	.150	.356		
USA	.643	.100	E-5.461	.800	.400	.600	.000	.001	
USA	6.6	E+3.010	1.43	E+4.000	4.65	E+2.000	1.43	E+2.070	
USA	9.3	E+6.49	E-31.43	E+71.28	.202	E-2			
USA	.012	.058	.460	E-21.34	E-3.000	.000	.000		
USA	.200	.200	.185	E-22.898	E+55.52	E+4.900	.220		
USA	.6991	.2926	.830	E-21.00	1.00	1.00	.015		

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```
C     HYDROLOGICAL MODEL
      DIMENSION WIC(55),WARG(55),WAG(55),TWG(55),WIG(55),WIRG(55),
     1  WDRG(55),WIL(55),WIRL(55),WWL(55),WDRL(55),WAL(55),WARL(55),
     2GRP(55),WI(55),POP(55),WD(55),WA(55),TWL(55),WAR(55),WAP(55),
     3WIP(55),WDP(55),WICP(55),TWS(55),XNLM(55),TSL(55),WDG(55),
     4 TWSWL(55)
      DIMENSION A(5,51),TINH(6),TIEH(6),GIWLA(6),GIWSA(6),GIWDA(6)
      DIMENSION NAME(12)
      REAL IPK,LS,INH
      EQUIVALENCE (WIL,WIP),(WDL,WDP)
      ISTAT = 1975
      MAXIYR = 2025
    1 WRITE(6,6040)
      READ(5,5001,END=4000) IREG
      DO 3 J=1,IREG
      READ(1,6050) (NAME(JJ),JJ=1,10)
      READ(1, 995) POP(1),GRP(1),WIW,WIRC,WC(1),WA(1),AL
      READ(1, 995) TWG(1),TWL(1),TWSWL(1),TWSI,WIC(1),XNLM(1),WI(1)
      READ(1,995) GRPR,WIK,IPK,WIAK,WILK,WIOK,WIGK
      READ(1,995) WIRK,WIRLK,WIROK,WIRGK,POPR,WDK,WDGK,WDLK
      READ(1,995) WDOK,WDWK,WDRK,WDRGK,WDRLK,WDROK,WAGK
      READ(1,995) WALK,WAGK,WAWK,WARK,WARGK,WARLK,WAROK,RLC
      READ(1,995) RLN,ROC,RON,SLC,SLN,SOC,SON,SMK
      READ(1, 995) LS,WLGSK,OS,WOASK,WGLK
      READ(1, 995) WLGK,WLOK,TWIMK,WOIPK,WOCPK,WOAPK
      READ(1, 995) WIRCK,WDRCK,EC,ENH,EH,EK,WICK
      READ(1, 995) WICLK,WICOK,WICGK,WICWK,WICRLK,WICRK,ALDR
    3 CONTINUE
C
C
  5   READ(2,5001) NMAX
      WRITE(6,5000)
      READ(5,5001) ISCEN
      IF (ISCEN .EQ. 99) GO TO 20
       DO 10 J = 1, NMAX
      READ(2, 995) GRWD,GRWI,GRWIC,GRWA,WLMIK,WLMOK,WLMAK,WLMICK
      READ(2, 995) WOSIK,WOSOK,WOSAK,WOSICK,WOICPK
      READ(2,995) WGAPK,WGDPK,WGIPK,WGICPK,WLAPK,WLDPK,WLIPK,WLICPK
      READ(2,995) (GIWLA(I),I=1,6)
      READ(2,995) (GIWSA(I),I=1,6)
      READ(2,995) (GIWDA(I),I=1,6)
      READ(2,995) (TINH(I), I=1,6)
      READ(2,995) (TIEH(I), I=1,6)
      READ(2, 112) ISWC1
      IF(J.EQ. ISCEN) GO TO 30
   10 CONTINUE
      WRITE(6,5002)
      REWIND 2
       GO TO 5
   20 CONTINUE
      READ(3, 995) GRWD,GRWI,GRWIC,GRWA,WLMIK,WLMOK,WLMAK,WLMICK
      READ(3, 995) WOSIK,WOSOK,WOSAK,WOSICK,WOICPK
      READ(3,995) WGAPK,WGDPK,WGIPK,WGICPK,WLAPK,WLDPK,WLIPK,WLICPK
      READ(3,995) (GIWLA(I),I=1,6)
      READ(3,995) (GIWSA(I),I=1,6)
      READ(3,995) (GIWDA(I),I=1,6)
```

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```
      READ(3,995) (TINH(I), I=1,6)
      READ(3,995) (TIEH(I), I=1,6)
      READ(3, 112) ISWC1
   30 CONTINUE
      WRITE(9,7040) (NAME(J),J=1,12),ISCEN
      WRITE(9,7010)
      WRITE(9,7000) GRWD,GRWI,GRWIC,GRWA
      WRITE(9,7020)
      WRITE(9,7000) WLMIK,WLMDK,WLMAK,WLMICK
      WRITE(9,7030)
      WRITE(9,7000) WDSIK,WDSDK,WDSAK,WDSICK
      WRITE(9,7090)
      WRITE(9,7000) WGAPK,WGDPK,WGIPK,WGICPK
      WRITE(9,8000)
      WRITE(9,7000) WLAPK,WLDPK,WLIPK,WLICPK
      WRITE(9,8100)
      WRITE(9,7000) WDAPK,WDDPK,WDIPK,WDICPK
      WRITE(9,7070)
      WRITE(9,7000) (GIWLA(JJ),JJ=1,6)
      WRITE(9,7080)
      WRITE(9,7000) (GIWSA(JJ),JJ=1,6)
      WRITE(9,7085)
      WRITE(9,7000) (GIWDA(JJ),J=1,6)
      WRITE(9,7050)
      WRITE(9,7000) (TINH(J),J=1,6)
      WRITE(9,7060)
      WRITE(9,7000) (TIEH(J),J=1,6)
C
C     CONSTANTS
C
      UMILLO = 1.E6
      CIENML = 1.E5
      DIZML  = 1.E4
      UMIL   = 1.E3
      CIEN   = 1.E2
      DIEZ   = 10.0
      UNO    = 1.0
      UDCM   = 1.E-1
      UCTSM  = 1.E-2
      UMLSM  = 1.E-3
      UDMLSM = 1.E-4
      UCMLS  = 1.E-5
      UMLLS  = 1.E-6
      UZMLLS = 1.0E-7
C
      KOUNT= MAXIYR-ISTAT+1
      WRITE(9,106)
      WRITE(9,902)
      IEAR = ISTAT
      DO 1000 IT=1,KOUNT
      GRP(IT+1) = GRP(IT)*(1.0 + GRPR)
      IF(ISWC1-1) 4305,4306,4305
 4306 WI(IT+1) = WI(IT) + GRWI
      GO TO 4316
 4305 WI(IT) = WIK*IPK*GRP(IT)
 4316 CONTINUE
```

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```
      WIL(IT) = WILK*WI(IT)
      WIO = WIOK*WI(IT)
      WIG(IT) = WIGK* WI(IT)
      WRITE(9,891) IEAR,GRP(IT),WI(IT),WIL(IT),WIG(IT),WIO
      A(1,IT) = GRP(IT)*UCTSM
      A(2,IT) = WI(IT)
      A(3,IT) = WIL(IT)
      A(4,IT) = WIG(IT)
      A(5,IT) = WIO
      IEAR = IEAR+1
 1000 CONTINUE
      WRITE(9,106)
      WRITE(9,900)
      WRITE(9,981)
      WRITE(9,992) UCTSM,UNO,UNO,UNO,UNO
      CALL BILD(A,5)
      IEAR = ISTAT
      WRITE(9,106)
      WRITE(9,901)
      DO 1200 J=1,KOUNT
      WIW = WIWK*WI(J)
      WIRC = WIRCK*WIW
      WIR = WIRK*WIW
      WIRL(J)=WIRLK*WIR
      WIRO = WIROK*WIR
      WIRG(J)=WIRGK*WIR
      WRITE(9,891) IEAR,WIW,WIR,WIRL(J),WIRO,WIRG (J),WIRC
      A(1,J) = WIW
      A(2,J) = WIR
      A(3,J) = WIRL(J)
      A(4,J) = WIRO*DIEZ
      A(5,J) = WIRG(J)*DIEZ
      IEAR=IEAR+1
 1200 CONTINUE
      WRITE(9,106)
      WRITE(9,996)
      WRITE(9,981)
      WRITE(9,992) UNO,UNO,UNO,DIEZ,DIEZ
      CALL BILD (A,5)
      WRITE(9,106)
      WRITE(9,902)
      IEAR = ISTAT
      DO 1400 J=1,KOUNT
      POP(J+1) = POP(J)*(1.2+POPR)
      IF(ISWC1-1) 1405,1410,1405
 1410 WD(J+1) = WD(J) + GP*D
      GO TO 1415
 1405 WD(J+1) = WD(J)*(1.0+POPR)
 1415 CONTINUE
      WDG(J)=WDGK*WD(J)
      WDL(J) = WDLK*WD(J)
      WDO = WDOK*WD(J)
      WRITE(9,891) IEAR,POP(J),WD(J),WDG(J),WDL(J),WDO
      A(1,J) = POP(J)*UZMLLS
      A(2,J) = WD(J)
      A(3,J) = WDG(J)
```

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```
      A(4,J) = WDL(J)
      A(5,J) = WDO
      IEAR = IEAR+1
 1400 CONTINUE
      WRITE(9,106)
      WRITE(9,902)
      WRITE(9,981)
      WRITE(9,992)UZMLLS,UNO,UNO,UNO,UNO
      CALL BILD (A,5)
      WRITE(9,106)
      WRITE(9,903)
      IEAR = ISTAT
      DO 1600 J=1,KOUNT
      WDW = WDWK*WO(J)
      WDR = WDRK*WDW
      WDRG(J) = WDRGK * WDR
      WDRL(J)     = WDRLK*WDR
      WDRO = WDROK*WDR
      WRITE(9,891) IEAR,WDW,WDR,WDRG(J),WDRL(J),WDRO
      A(1,J) = WDW
      A(2,J) = WDR
      A(3,J) = WDRG(J)*DIEZ
      A(4,J) = WDRL(J)
      A(5,J) = WDRO*DIEZ
      IEAR = IEAR+1
 1600 CONTINUE
      WRITE(9,106)
      WRITE(9,903)
      WRITE(9,981)
      WRITE(9,992) UNO,UNO,DIEZ,UNO,DIEZ
      CALL BILD (A,5)
      WRITE(9,106)
      WRITE(9,904)
      IEAR = ISTAT
      AL = AL*(1.0 - ALDR)
      DO 1800 J=1,KOUNT
      IF(IS*C1-1) 1805,1810,1805
 1810 WA(J+1)=WA(J)+GRWA
      GO TO 1815
 1805 WA(J+1)=WA(J)*(1.0+ALDR)
 1815 CONTINUE
      WAW = WAWK*WA(J)
      WAR(J) = WARK*WAW
      WAG(J) = WAGK*WA(J)
      WAL(J) = WALK*WA(J)
      WAO    = WAOK*WA(J)
      AL = AL*(1.0+ALDR)
      WRITE(9,891) IEAR,AL,WA(J),WAG(J),WAL(J),WAO
      A(1,J) = AL*UDMLSM
      A(2,J) = WA(J)
      A(3,J) = WAG(J)
      A(4,J) = WAL(J)
      A(5,J) = WAO * DIZML
      IEAR = IEAR+1
 1800 CONTINUE
      WRITE(9,106)
```

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```
      WRITE(9,904)
      WRITE(9,981)
      WRITE(9,992) UOMLSM,UNO,UNO,UNO,DIZML
      CALL BILD (A,5)
      WRITE(9,106)
      WRITE(9,906)
      IEAR = ISTAT
      DO 2200 J=1,KOUNT
      WAW = WAWK*WA(J)
      WARG(J) = WARGK*WAR(J)
      WARL(J) = WARLK*WAR(J)
      WARO = WAROK*WAR(J)
      WRITE(9,691) IEAR,WAW,WAR(J),WARG(J),WARL(J),WARO
      A(1,J) = WAW
      A(2,J) = WAR(J)
      A(3,J) = WARG(J)
      A(4,J) = WARL(J)
      A(5,J) = WARO
      IEAR = IEAR+1
 2200 CONTINUE
      WRITE(9,106)
      WRITE(9,906)
      WRITE(9,981)
      WRITE(9,992) UNO,UNO,UNO,UNO,UNO
      CALL BILD (A,5)
      WRITE(9,106)
      WRITE(9,908)
      IEAR = ISTAT
      DO 2600 J=1,KOUNT
      IF(ISWC1-1) 2605,2610,2605
 2610 WIC(J+1) = WIC(J)+GRWIC
      GO TO 2615
 2605 WIC(J) = WICK*GRP(J)
 2615 CONTINUE
      WICL=WICLK*WIC(J)
      WICO = WICOK*WIC(J)
      WICG = WICGK*WIC(J)
      WRITE(9,892) IEAR,WIC(J),WICL,WICG,WICO
      A(1,J) = WIC(J)
      A(2,J) = WICL
      A(3,J) = WICG*CIEN
      A(4,J) = WICO*CIEN
      A(5,J) = 0.0
      IEAR = IEAR+1
 2600 CONTINUE
      WRITE(9,106)
      WRITE(9,908)
      WRITE(9,982)
      WRITE(9,993) UNO,UNO,CIEN,CIEN
      CALL  BILD (A,4)
      WRITE(9,106)
      WRITE(9,909)
      IEAR = ISTAT
      DO 2800 J=1,KOUNT
      WICW=WICWK*WIC(J)
      WICRL=WICRLK*WIC(J)
```

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```
      WICR=WICRK*WIC(J)
      WRITE(9,893) IEAR,WICW,WICR,WICRL
      A(1,J) = WICW
      A(2,J) = WICR
      A(3,J) = WICRL
      A(4,J) = 0.0
      IEAR = IEAR+1
 2800 CONTINUE
      WRITE(9,106)
      WRITE(9,909)
      WRITE(9,983)
      WRITE(9,994) UNO,UNO,UNO
      CALL BILD(A,3)
      RL =(1.0+RLC)*RLN
      RO = (1.0+ROC)*RON
      SL = (1.0+SLC)*SLN
      SO = (1.0+SOC)*SON
      WLA = WLASK*LS
      WOA = WOASK*OS
      DO 3000 J=1,KOUNT
      TSL(J)=(1.0-SMK)*SL
      WSL = SMK*TSL(J)
 3000 CONTINUE
      WRITE(9,106)
      WRITE(9,911)
      TWS(1)=TWSI
      IEAR = ISTAT
      DO 3200 K=1,5
      DIFF = GIWLA(K+1) - GIWLA(K)
      DIFF1 = GIWSA(K+1) - GIWSA(K)
      DIFF2 = GIWOA(K+1) - GIWOA(K)
      KK = (KOUNT-1)/5
      DO 3200 L=1,10
      J = (K-1)*KK +L
      GIWL = GIWLA(K) + DIFF*L/KK
      GIWS = GIWSA(K) + DIFF1*L/KK
      GIWO = GIWOA(K) + DIFF2*L/KK
      XWLM(J+1) = XWLM(J)+GIWL
      TWS(J+1) = TWS(J)+GIWS
      TWSWL(J+1) = TWSWL(J) + GIWO
      WICG   =WICGK*WIC(J)
      WGL    = WGLK*TWG(J)
      WLG    =WLGK*TWL(J)
      TWG(J+1)= TWG(J)+WLG-WGL-WIG(J)+WIRG(J)-WDG(J)+WDRG(J)-WAG(J)+
     1 WARG(J)-WICG
      WLO = WLOK * TWL(J)
      TWL(J+1) = TWL(J)+WGL- WLG -WIL(J)+WIRL(J)-WDL(J)+WDRL(J)-WAL(J)+
     1WARL(J) + RL + TSL(J) - WLO - WLA
      WRITE(9,891) IEAR,TWG(J),WGL,XWLM(J),WLO,WLG
      A(1,J) = TWG(J)*UMLSM
      A(2,J) = WGL * UOCM
      A(3,J) = XWLM(J)
      A(4,J) = WLO
      A(5,J) = WLG
      IEAR = IEAR+1
 3200 CONTINUE
```

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```
      J = KOUNT
      IEAR = MAXIYR
      WLG  =WLGK*TWL(J)
      WGL  = WGLK*TWG(J)
      WLO = WLOK * TWL(J)
      WRITE(9,891) IEAR,TWG(J),WGL,XWLM(J),WLO,WLG
      A(1,J) = TWG(J)*UMLSM
      A(2,J) = WGL * UDCM
      A(3,J) = XWLM(J)
      A(4,J) = WLO
      A(5,J) = WLG
      WRITE(9,106)
      WRITE(9,911)
      WRITE(9,981)
      WRITE(9,992) UMLSM,UDCM,UNO,UNO,UNO
      CALL BILD(A,5)
      IEAR = ISTAT
      WRITE(9,106)
      WRITE(9,912)
      DO 3400 J=1,KOUNT
      TWIM = TWIMK*TWL(J)
      WRITE(9,891) IEAR,TWL(J),TWIM
      A(1,J) = TWL(J)/10.0
      A(2,J) = TWIM
      A(3,J) = 0.0
      A(4,J)=0.0
      A(5,J)=0.0
      IEAR=IEAR+1
 3400 CONTINUE
      WRITE(9,106)
      WRITE(9,912)
      WRITE(9,983)
      WRITE(9,992) UDCM,UNO
      CALL BILD(A,2)
      IEAR=ISTAT
      WRITE(9,106)
      WRITE(9,920)
      DO 3450 J=1,KOUNT
      WLIP = WLIPK*TWL(J)
      WOIP = WOIPK*TWSWL(J)
      WGIP = WGIPK*TWG(J)
      WOSIP = WOSIK*TWS(J)
      WLMIP = WLMIK * XWLM(J)
      WIP(J)=WLIP+WOIP+WGIP+WOSIP+WLMIP
      WRITE(9,891) IEAR,WLIP,WOIP,WGIP,WOSIP,WLMIP
      A(1,J) = WLIP
      A(2,J) = WOIP
      A(3,J) = WGIP
      A(4,J) = WOSIP
      A(5,J) = WLMIP
      IEAR = IEAR+1
 3450 CONTINUE
      WRITE(9,106)
      WRITE(9,920)
      WRITE(9,981)
      WRITE(9,992) UNO,UNO,UNO,UNO,UNO
```

```
      CALL  BILD(A,5)
      IEAR = ISTAT
      WRITE(9,106)
      WRITE(9,913)
      DO 3600 J=1,KOUNT
      WLDP = WLDPK*TWL(J)
      WODP = WODPK*TWSWL(J)
      WGDP = WGDPK*TWG(J)
      WOSDP = WOSDK*TWS(J)
      WLMDP = WLMDK*XWLM(J)
      WDP(J) = WLDP + WODP + WGDP + WOSDP + WLMDP
      WRITE(9,891) IEAR,WLDP,WODP,WGDP,WOSDP,WLMDP
      A(1,J) = WLDP
      A(2,J) = WODP
      A(3,J) = WGDP
      A(4,J) = WOSDP
      A(5,J) = WLMDP
      IEAR = IEAR+1
 3600 CONTINUE
      WRITE(9,106)
      WRITE(9,913)
      WRITE(9,981)
      WRITE(9,992) UNO,UNO,UNO,UNO,UNO
      CALL BILD(A,5)
      IEAR = ISTAT
      WRITE(9,126)
      WRITE(9,915)
      DO 3650 J=1,KOUNT
      WLAP = WLAPK*TWL(J)
      WOAP = WOAPK*TWSWL(J)
      WGAP = WGAPK*TWG(J)
      WOSAP= WOSAK*TWS(J)
      WLMAP = WLMAK*XWLM(J)
      WAP(J)=WLAP+WOAP+WGAP+WOSAP+WLMAP
      WRITE(9,891) IEAR,WLAP,WOAP,WGAP,WOSAP,WLMAP
      A(1,J)=WLAP
      A(2,J) = WOAP
      A(3,J) = WGAP
      A(4,J) = WOSAP
      A(5,J) = WLMAP
      IEAR = IEAR+1
 3650 CONTINUE
      WRITE(9,106)
      WRITE(9,915)
      WRITE(9,981)
      WRITE(9,992) UNO,UNO,UNO,UNO,UNO
      CALL BILD (A,5)
      IEAR = ISTAT
      WRITE(9,106)
      WRITE(9,917)
      DO 3700 J=1,KOUNT
      WLICP=WLICPK*TWL(J)
      WOICP = WOICPK*TWSWL(J)
      WGICP = WGICPK*TWG(J)
      WOSICP = WOSICK*TWS(J)
      WLMICP=WLMICK*XWLM(J)
```

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```
      WICP(J) = WLICP+WOICP+WOSICP+WLMICP+WGICP
      WRITE(9,891) IEAR,WLICP,WOICP,WGICP,WOSICP,WLMICP
      A(1,J)=WLICP
      A(2,J)=WOICP
      A(3,J) = WGICP
      A(4,J) = WOSICP
      A(5,J)=WLMICP
      IEAR = IEAR+1
 3700 CONTINUE
      WRITE(9,106)
      WRITE(9,917)
      WRITE(9,981)
      WRITE(9,992) UNO,UNO,UNO,UNO,UNO
      CALL  BILD(A,5)
      IEAR = ISTAT
      WRITE(9,106)
      WRITE(9,925)
      DO 3725 J=1,KOUNT
      WRITE(9,891) IEAR,WIP(J),WDP(J),WAP(J),WICP(J)
      A(1,J)=WIP(J)
      A(2,J)=WDP(J)
      A(3,J)=WAP(J)
      A(4,J)=WICP(J)
      A(5,J)=0.0
 3725 IEAR = IEAR+1
      WRITE(9,106)
      WRITE(9,925)
      WRITE(9,982)
      WRITE(9,992) UNO,UNO,UNO,UNO
      CALL BILD (A,4)
      IEAR = ISTAT
      WRITE(9,106)
      WRITE(9,918)
      DO 3750 J=1,KOUNT
      SWI=WIP(J)-WI(J)
      SWD=WDP(J)-WD(J)
      SWA = WAP(J)-WA(J)
      SWIC = WICP(J)-WIC(J)
      WRITE(9,891) IEAR,SWI,SWD,SWA,SWIC
      A(1,J)=SWI
      A(2,J)=SWD
      A(3,J)=SWA
      A(4,J)=SWIC
      IEAR=IEAR+1
 3750 CONTINUE
      WRITE(9,106)
      WRITE(9,918)
      WRITE(9,982)
      WRITE(9,992) UNO,UNO,UNO,UNO
      CALL BILD(A,4)
      IEAR = ISTAT
      WRITE(9,106)
      WRITE(9,916)
      DO 3850 J=1,KOUNT
      KK = (J+3)/10+1
      ENH = ENH + TINH(KK)*1.E3
```

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```
      EH = EH + TJEH(KK)*1.E3
      SE = -EC*PCP(J)+(ENM+EK*EH)
      WRITE(9,892) IEAR,TWS(J),ENM,EH,SE
      A(1,J)=TWS(J)*DIEZ
      A(2,J) =ENM*1.E-7
      A(3,J)=EH*1.E-2
      A(4,J)=SE*1.E-3
      IEAR = IEAR+1
 3850 CONTINUE
      WRITE(9,106)
      WRITE(9,916)
      WRITE(9,982)
      WRITE(9,992) DIEZ,UNO,UCTMS,UMLSM
      CALL BILD (A,4)
C
C     INDICATORS
C
      IEAR = ISTAT
      WRITE(9,106)
      WRITE(9,914)
      DO 3800 J=1,KOUNT
      FACT = WI(J)+WD(J)+WA(J)
      PIND1 = FACT/TWL(J)
      PIND2 = FACT/TWG(J)
      WRITE(9,891) IEAR,FACT,PIND1,PIND2
      A(1,J)=FACT
      A(2,J)= PIND1*1.E05
      A(3,J)=PIND2*1.E06
      A(4,J)=0.0
      IEAR = IEAR+1
 3800 CONTINUE
      WRITE(9,106)
      WRITE(9,914)
      WRITE(9,993) UNO,CIENML,UMILLO
      CALL BILD(A,3)
      GO TO 1
 4000 CONTINUE
C
C
  106 FORMAT(1H1,20X,'   ')
  112 FORMAT(8X,I2)
  115 FORMAT(7F5.0)
  116 FORMAT(6E10.3)
  891 FORMAT(1H ,I5,5X,6(1X,E10.3,2X))
  892 FORMAT(1H ,I5,5X,5(1X,E10.3,2X))
  893 FORMAT(1H ,I5,5X,3(1X,E10.3,2X))
  900 FORMAT(1H/,1X,15X,'GEP',10X,'WI',10X,'WIL',10X,'WIG',10X,'WIO')
  901 FORMAT(1H0, 14X,'WIW',10X,'WIR',10X,'WIRL',9X,'WIRO',9X,'WIRG', 9X
     1,'WIRC')
  902 FORMAT(1H0,14X,'POP',10X,'WD',11X,'WDG',10X,'WDL',10X,'WDO')
  903 FORMAT(1H0,14X,'WDW',10X,'WDR',10X,'WDRG',9X,'WDRL',9X,'WDRO')
  904 FORMAT(1H0,14X,'AL',12X,'WA',11X,'WAG',10X,'WAL',8X,'WAO')
  905 FORMAT(1H0,14X,'WPN',8X,'WA',8X,'WAG',8X,'WAL',8X,'WAO')
  906 FORMAT(1H0,14X,'WAW',10X,'WAR',10X,'WARG', 9X,'WARL',9X,'WARO')
  907 FORMAT(1H0,16X,'RL',10X,'RU',10X,'SL',12X,'SO',11X,'TSL')
  908 FORMAT(1H0,15X,'WIC',10X,'WICL',8X,'WICG',8X,'WICO')
```

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```
  909 FORMAT(1H0,14X,'WICN', 9X,'WICR', 9X,'WICRL')
  910 FORMAT(1H0,16X,'WLA',10X,'WOA',10X,'WSL')
  911 FORMAT(1H0,14X,'TWG',10X,'WGL',10X,'TWLM', 9X,'WLO',10X,'WLG')
  912 FORMAT(1H0,14X,'TWL',10X,'TWIM')
  913 FORMAT(1H0,14X,'WLDP', 9X,'WODP', 9X,'WGDP',7X,'WOSDP',10X,'WLMDP'
     1)
  914 FORMAT(1H0,14X,'FACT', 9X,'PIND1', 8X,'PIND2')
  915 FORMAT(1H0,16X,'WLAP',10X,'WOAP',7X,'WGAP',8X,'WOSAP',8X,'WLMAP')
  916 FORMAT(1H0,14X,'TWS',10X,'ENH',10X,'EH',11X,'SE')
  917 FORMAT(1H0,14X,'WLICP',7X,'WOICP',8X,'WGICP',8X,'WOSICP',8X,'WLMIC
     1P')
  918 FORMAT(1H0,14X,'SWI',10X,'SWD',10X,'SWA',10X,'SWIC')
  920 FORMAT(1H0,14X,'WLIP', 9X,'WOIP', 9X,'WGIP',8X,'WOSIP',8X,'WLMIP')
  925 FORMAT(1H0,14X,'WIP',10X,'WOP',10X,'WAP',10X,'WICP')
  981 FORMAT(1X,15X,'1',12X,'2',12X,'3',12X,'4',12X,'5')
  982 FORMAT(1X,15X,'1',12X,'2',12X,'3',12X,'4')
  983 FORMAT(1X,15X,'1',12X,'2',12X,'3')
  991 FORMAT(1X,11I10)
  992 FORMAT(1X,10X,6(E10.3,3X))
  993 FORMAT(1X,10X,4(E10.3,3X))
  994 FORMAT(1X,10X,3(E10.3,3X))
  995 FORMAT(8X,8E9.4)
  996 FORMAT(1H0, 14X,'WIW',10X,'WIR',10X,'WIRL',9X,'WIRO',9X,'WIRG')
 5000 FORMAT(' SCENARIO NUMBER , E.G. 03 ',/)
 5001 FORMAT(I2)
 5002 FORMAT(' SCENARIO NUMBER NOT EXISTENT - TRY AGAIN ',/)
 6040 FORMAT(' ENTER REGION, E.G. 06 ',/)
 6050 FORMAT(12A2)
 7000 FORMAT(1H ,6(8X,E12.5))
 7010 FORMAT(1H0,12X,'GRWP',16X,'GRWI',16X,'GRWIC',15X,'GRWA')
 7020 FORMAT(1H0,13X,'WI',17X,'WLMIK',15X,'WLMDK',15X,'WLMAK',14X,'WLMIC
     1K')
 7030 FORMAT(1H0,12X,'WOSIK',15X,'WOSDK',15X,'WOSAK',14X,'WOSICK')
 7040 FORMAT(1H1,12A2,40X,'SCENARIO RUN ',I2)
 7050 FORMAT(1H0,11X,'TINH(1)',13X,'TINH(2)',13X,'TINH(3)',13X,'TINH(4)'
     1,13X,'TINH(5)',13X,'TINH(6)')
 7060 FORMAT(1H0,11X,'TIEH(1)',13X,'TIEH(2)',13X,'TIEH(3)',13X,'TIEH(4)'
     1,13X,'TIEH(5)',13X,'TIEH(6)')
 7070 FORMAT(1H0,11X,'GIWL(1)',13X,'GIWL(2)',13X,'GIWL(3)',13X,'GIWL(4)'
     1,13X,'GIWL(5)',13X,'GIWL(6)')
 7080 FORMAT(1H0,11X,'GIWS(1)',13X,'GIWS(2)',13X,'GIWS(3)',13X,'GIWS(4)'
     1,13X,'GIWS(5)',13X,'GIWS(6)')
 7085 FORMAT(1H0,11X,'GIWO(1)',13X,'GIWO(2)',13X,'GIWO(3)',13X,
     1 'GIWO(4)',13X,'GIWO(5)',13X,'GIWO(6)')
 7090 FORMAT(1H0,12X,'WGAPK',15X,'WGDPK',15X,'WGIPK',14X,'WGICPK')
 8000 FORMAT(1H0,12X,'WLAPK',15X,'WLDPK',15X,'WLIPK',14X,'WLICPK',14X,'W
     1OICPK')
 8100 FORMAT(1H0,12X,'WOAPK',15X,'WODPK',15X,'WOIPK',14X,'WOICPK')
      STOP
      END
```

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```
      SUBROUTINE BILD(EING,NR,NMAX)
      DIMENSION FELD(122),EING(5,121),Z(51),CL(5)
      DATA STR/'-'/,BL/' '/,SPA/'I'/
      DATA CL/'1','2','3','4','5'/
      XMAX = EING(1,1)
      XMIN = XMAX
      JJ = NMAX - 1
      DO 10 J = 1,JJ
      DO 10 I = 1,NR
      X = XMAX - EING(I,J)
      IF(X .LT. 0) XMAX = EING(I,J)
      X = XMIN - EING(I,J)
      IF(X .GT. 0) XMIN = EING(I,J)
   10 CONTINUE
      IF(XMAX .NE. XMIN) GO TO 15
      XMAX=XMAX + 0.5
      XMIN = XMIN - 0.5
   15 DIFF = XMAX - XMIN
      SPR = DIFF/50.0
      Z(1) = XMAX
      Z(51) = XMIN
      DO 20 K = 2,50
      Z(K) = Z(K-1) - SPR
   20 CONTINUE
      Y = SPR/2.0
      NZ = 50
      DO 80 K = 1,51
      NZ = NZ + 1
      IF(NZ .EQ. 51) GO TO 50
      DO 40 I1 = 2,122
   40 FELD(I1) = BL
      DO 45 I1 = 2,122,10
   45 FELD(I1) = SPA
      GO TO 60
   50 DO 55 I1 = 2,122
   55 FELD(I1) = STR
      NZ = 1
   60 CONTINUE
      FELD(1) = Z(K)
      DO 70 I = 1,NR
      DO 65 J = 2,122
      A = EING(I,J) - Z(K)
      IF(A .LT. -Y) GO TO 65
      IF(A .GT.  Y) GO TO 65
      FELD(J) = CL(I)
   65 CONTINUE
   70 CONTINUE
   80 WRITE(9,1000) (FELD(J), J=1,NMAX)
C
C
 1000 FORMAT(1X,E11.4,2X,115A1)
      RETURN
      END
```

References

[1] Oehmen, K.H., and Paul, W. "Construction of Population Submodels." IIASA Symposium Proceedings SP-74-3, pp. B362-B480.

[2] Clapham, W.B., Shook, T., and Warshaw, M.W. "A Regionalized Food Model for the Global System." IIASA Symposium Proceedings SP-74-3, pp. B500-B554.

[3] Mesarovic, M.D., Richardson, J.M. Jr., Shook, T., and Warshaw, M.W. "The Structural Description and Sensitivity Analysis of the Food Submodel." IIASA Symposium Proceedings SP-74-3, pp. B556-B626.

[4] Gottwald, M., and Pestel, R. "Environmental Impact Assessment." IIASA Symposium Proceedings SP-74-5 pp. B1122-B1276.

[5] Rechenmann, F. "Conversational Use of Multi-Layer Decision Models." IIASA Symposium Proceedings SP-74-6, pp. C232-C246.

[6] Cardenas, M.A., and Huerta, J.M. "Submodel of Global Water Cycle on Regional Basis." IIASA Symposium Proceedings SP-74-5, pp. B1278-B1391.

[7] Heyes, R.P., Jerdonek, R.A., and Kuper, A.B. "Global Energy Submodel." IIASA Symposium Proceedings SP-74-5, pp. B1084-B1119.

[8] Bossel, H. "Energy Supply Submodel." IIASA Symposium Proceedings SP-74-4, pp. B834-B970.