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KYBASIN: A Water Supply Assessment Model for the Kentucky River Basin

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KENTUCKY RIVER BASIN WATER SUPPLY ASSESSMENT STUDY

KYBASIN

A Water Supply Assessment Model for the Kentucky River Basin

User's Manual

J. Herman
L. Ormsbee

Prepared for:
The Kentucky River Authority

By:
The Kentucky Water Resource Research Institute
University of Kentucky
Lexington, Kentucky

SEPTEMBER 1996
KWRRI

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Contents

Disclaimer

Although reasonable effort has been made to assure that the results obtained are correct, neither the authors, nor the KWRRI, assumes any responsibility for any results or any use made of the results obtained with the model. This software is provided "AS IS", and the user assumes all risks when using it.

KYBASIN User's Manual

Introduction

KYBASIN is a computer model developed for the Kentucky River Authority by the Kentucky Water Resource Research Institute (KWRRI) for the express purpose of simulating the Kentucky River Basin under a severe drought. The model was developed as part of the KWRRI Kentucky River Basin Water Supply Assessment Study. This study was authorized by the KRA in a contract with the KWRRI dated April 1, 1995. Ownership of the model is exclusively that of the Authority and specific rules governing KYBASIN's distribution or license agreement may be applicable. It is strongly recommended the user contact the Authority concerning this matter before using the model.

System Requirements

To use the KYBASIN model, you need:

- An IBM® compatible machine with at least a 80486 processor or higher. A pentium 100 MgHz machine or higher is recommended.
- A CD-ROM optical drive.
- Approximately 45 megabytes of unused hard drive memory.
- A licensed copy of Microsoft® Excel.

How To Install

The KYBASIN model is comprised of seven files (listed below) which are located on the CD that was provided with this manual.

INOUT1.XLS	ENGIN1.XLS
ENGIN2.XLS	ENGIN3.XLS
ENGIN4.XLS	DMS.XLS
DFM.XLS	

These files must be copied onto your computer's hard drive into a directory entitled "KBASIN1". If no KBASIN1 directory exists, one must be created.

The procedure to make a KBASIN1 directory and install the program files on your computer's hard drive is dependent upon the operating system of the computer. Follow the installation steps listed below for your operating system.

Windows 3.X

1. Go to the Windows File Manager. The File Manager is located in the Main program group.

2. In the left window select the "C:\" folder located at the top of the directory tree. (You may have to use the scroll bars.)

3. From the File Manager select "File" on the menu bar located at the top of the screen. Then select Create Directory from the File menu.

4. A pop-up window will appear prompting you to enter the directory name. Type "KBASIN1" in the box provided. Then click the OK button to create the KBASIN1 directory.

5. Next go to the CD drive by selecting it from the drive boxes located above the directory and file windows. The left window should now show two directories named "KYBASIN" and "KVDM".

6. Click the KYBASIN folder from the directory tree in the left window. The right window should now contain the seven program files identified earlier.

7. Highlight the seven files with the mouse, then select Copy from the File menu located at the top of the screen. A pop-up window will appear prompting you to enter the destination of the copied files. Type "C:\KBASIN1" in the box provided and press the OK button.

8. The program is now installed on you hard drive. Select Exit from the File menu at the top of the screen to exit the File Manager.

Windows '95

1. Go to the Windows Explorer. The Explorer is usually the last item in the Programs menu. The Programs menu is displayed when you click on the Start button located at the bottom left-hand corner of the desktop.

2. In the left window of the Explorer highlight the hard drive (C:\) item in the directory tree. (The hard drive is usually located near the top of the tree.)

3. Next select "File" from the menu bar located at the top of the screen. Then select New from the menu. Another menu will appear, select Folder from the list.

4. A new directory will appear in the right window labeled "New Folder". Change the name of this folder to "KBASIN1".

5. Next go to the CD drive by selecting it from the left window. The right window should now show two directories named "KYBASIN" and "KVDM".

6. Click the KYBASIN folder in the right window. The right window should now contain the seven program files identified earlier.

7. Highlight the seven files with the mouse. This is done by holding down the CTRL button on the keyboard and clicking on each file individually with the mouse. Once all the files have been selected, right-click the mouse on any of the highlighted files. A small menu will appear; select Copy.

8. Next right-click on the KBASIN1 directory located in the left window. From the small menu that appears select Paste.

9. The program is now installed on you hard drive. Click on the X located at the top right-hand side of your screen to exit the Windows Explorer.

Starting the Model

There are two ways to start the KYBASIN model. The first method is from the Excel program. To do this select Open from the File menu in Excel. At the common dialog box that appears, select the INOUT1.XLS file (located in the C:\KBASIN1 directory), then press the OK button and the model will be loaded.

The second method to start the KYBASIN model is from the Windows File Manager or Windows '95 Explorer. To do this, simply locate the file in the KBASIN1 directory and double-click on it with the mouse. The computer will then open KYBASIN in the Excel environment for you.

The first method is recommended for those familiar with the Excel program. For those unfamiliar with Excel the second method is recommended. If your computer has severe memory restrictions, the first method is strongly recommended, since it does not require the File Manager/Explorer program to be open concurrently with the KYBASIN program.

Model Structure

KYBASIN is comprised of seven Microsoft® Excel spreadsheet files. Only one file (INOUT1.XLS) is accessed by the user directly. The other files are accessed automatically by the computer during run time. Figure 1 illustrates this interaction between the seven files. The INOUT1 file is the Input/Output Module (or IOM) for KYBASIN. The IOM is the sole interface between KYBASIN and the user. The IOM is where all user input is entered and model output is displayed. The four ENGIN#.XLS files are responsible for performing the calculations necessary to simulate the river for the 12-month analysis period. Each ENGIN#.XLS file completely simulates a 3-month period. These files are called by the computer when the user requests (from the IOM) a simulation to be performed. The DMD.XLS file contains a select database of predefined municipal demands. These databases can be loaded into the KYBASIN model. The DFM.XLS file contains the Demand Forecast Model (DFM) developed by the UK/KWRRI Economics Group. The DFM file allows the user to generate municipal demand forecasts and was used to generate the demand databases in the DMD.XLS file. The DFM file has been integrated into the KYBASIN model to facilitate direct importation of user-generated demand forecasts into the model.

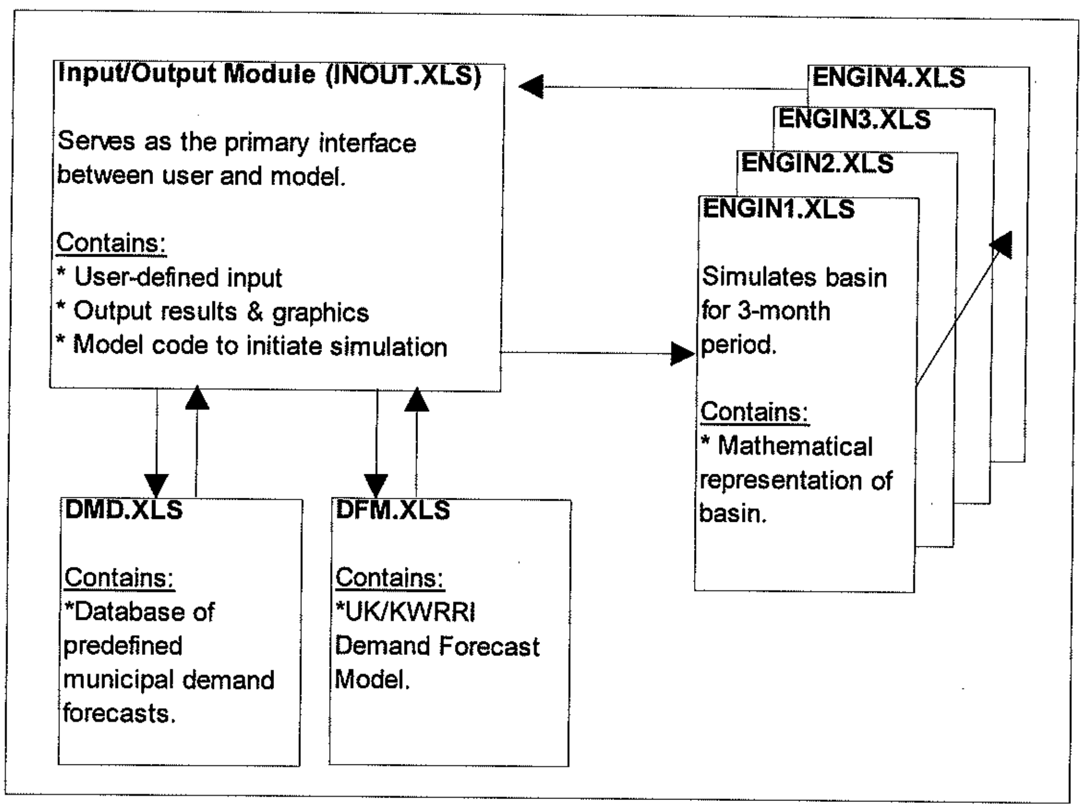


Figure 1: Flow chart of KYBASIN model structure

Model Overview

The KYBASIN model has been developed for the express purpose of simulating the Ky. River Basin under a severe drought. The model utilizes user-defined values for basin parameters, demands, and a specified drought to simulate water movement and exchanges in the basin for a 12-month period. By emulating river behavior, water supply shortages/deficits on the river are identified and quantified.

This model is intended as a tool, designed for use in developing long-range water supply plans for the Ky. River Basin. By simulating river behavior under different physical system configurations, decision-makers can "see" the impact of competing alternatives on water supply. This can greatly enhance planning efforts by providing an estimate of the effectiveness of different alternatives at reducing deficits *before* they are implemented. This can assist decision-makers in ranking alternatives by providing information for a cost-benefit analysis. Additionally, the model can assist in water supply planning negotiations between conflicting user groups by providing answers to potential system changes, as opposed to relying on ad hoc hypotheses about the system response to these changes.

The model can accommodate alternatives involving any combination of the following river system changes:

1. Addition of low-level release valves on any or all of the lock and dam locations #9 - #14.
2. Addition of crest gates on any or all of the lock and dam locations #9 - #14.
3. Changes in DOW minimum flow requirement values.
4. Repair/degradation of lock and dam leakage.
5. Permanent increases in dam crest elevations (< 5 feet).
6. Raising/lowering withdrawal intakes.
7. Increases/reduction in existing municipal, industrial, commercial, and irrigation demands.
8. Addition of a new demand/withdrawal on the river.
9. Changes in reservoir releases / rule curve strategy.

Model Methodology

The KYBASIN model was created as part of a study funded by the Authority to assess water supply availability in the basin during severe drought periods. Consequently, much of the assumptions and underlying methodology KYBASIN uses to simulate water movement in the basin is contained in the Task III Deficit Analysis (KWRRI, 1996) report prepared for that study (Figure 2). Since the goal of this manual is to familiarize the user with how to use the model, rather than provide a detailed account of model assumptions, most of the methodology has been omitted from this manual. Those interested in the methodology / theory used by the model to generate results are encouraged to consult the Task III Deficit Analysis report for a more complete discussion.

Select portions of the methodology are introduced in this manual. This information is provided to inform users how certain data inputs will be interpreted by the model. This is necessary to ensure an accurate characterization of the river system by the user. This information is contained in the How Do I ... sections of the report.

KENTUCKY RIVER BASIN WATER SUPPLY ASSESSMENT STUDY

TASK III - DEFICIT ANALYSIS

Prepared for:
The Kentucky River Authority

Prepared by:
The Kentucky Water Resource Research Institute
University of Kentucky
Lexington, Kentucky

AUGUST 1996

Figure 2: KWRRI report that contains a complete discussion of KYBASIN's modeling methodology.

What You Need To Do To Perform a Simulation

1. Become familiar with the menu system.

The KYBASIN menu system was designed to facilitate use of the model and was designed with simplicity in mind. As illustrated in the virtual tour, there are two menu systems: the main menu which is activated from clicking on the basin map and the menubar at the top of the screen. The main menu is the primary menu system that is used by the user to perform simulations. It contains those items/data that the user will change frequently (i.e. municipal demands, reservoir releases, etc.). The menubar contains those items which will likely only be changed infrequently (i.e. stage-storage data, return flow percentages, etc.). All input data necessary to perform a simulation can be accessed from the main menu. The menubar need only be accessed if you wish to change KYBASIN's default databases.

2. Enter input data.

The following data must be provided by the user in order to perform a realistic simulation.

- ☒ municipal demands
- ☒ irrigation demands
- ☒ dam crest elevations
- ☒ critical intake elevations
- ☒ design drought
- ☒ reservoir transmission losses
- ☒ crest gate locations (optional)
- ☒ low-level valve locations (optional)
- ☒ lock leakage
- ☒ initial water levels
- ☒ minimum flow requirements
- ☒ maximum reservoir releases
- ☒ reservoir rule curves
- ☒ reservoir leakage
- ☒ crest gate strategy (optional)
- ☒ valve strategy (optional)

The input screens for the above data may be accessed through the Main Menu. The remaining data below has default databases that were generated by the KWRRI during the Kentucky River Basin Water Supply Assessment Study for the Authority in 1996. This data reflects KWRRI's "best guess" for these parameters and is largely reflective of the published Corps of Engineers data for these parameters at the time. The user may change these parameters by accessing them through the menubar located at the top of the screen.

- ☒ pool stage-storage data
- ☒ lock stage-discharge data
- ☒ reservoir stage-area data
- ☒ evaporation data
- ☒ pool stage-area data
- ☒ reservoir stage-storage data
- ☒ return flow percentages
- ☒ design drought inflow traces

Specific step-by-step instructions on how to enter/modify all of the above data items are provided in the How Do I ... sections in the back of this manual. These sections also provide a detailed description of each data item and identify the format in which they must be entered.

It should be noted that there may already be data entered in many of the input screens. This data is 'old' data remaining from a previous simulation. It is important to make sure you check all the input screens before performing a simulation, to ensure unwanted 'leftover' input does not apply to the current simulation.

3. Perform the simulation.

Once all input has been entered/verified into the computer, a simulation may be performed at any time by selecting it from the main menu. A simulation takes approximately 12-13 minutes on a Pentium 166 MHz machine. Run times will vary depending upon machine type and configuration.

4. View output.

When a simulation is completed a pop-up menu will appear informing the user that results have been generated. At this juncture the output may be reviewed. To do this select the View Output option from the main menu. Output may be viewed in a graphical or tabular format. To view output in tabular form the user can either use the menubar or use the button provided by the graphical output screen.

There are three outputs from the KYBASIN model. Output is provided on a daily basis over the 12-month analysis period for mainstem pools and major reservoirs. Output consists of: end-of-day storages, river flows, and deficits. Storages reflect water levels in the impoundment at the end of each day. River flows denote both flow over and through locks and dams. Deficits represent the sum of unsatisfied municipal demands in a reach or impoundment.

Output is viewed by first, selecting the location/impoundment from the listbox at the left of the output screen and secondly, pressing the UPDATE button. To change the output type, simply press the desired output parameter from the buttons located at the top of the output screen.

It is important to keep in mind that model output is static, reflecting input data at the time the simulation was performed, and changes in input parameters will not be reflected in the output until another simulation is requested.

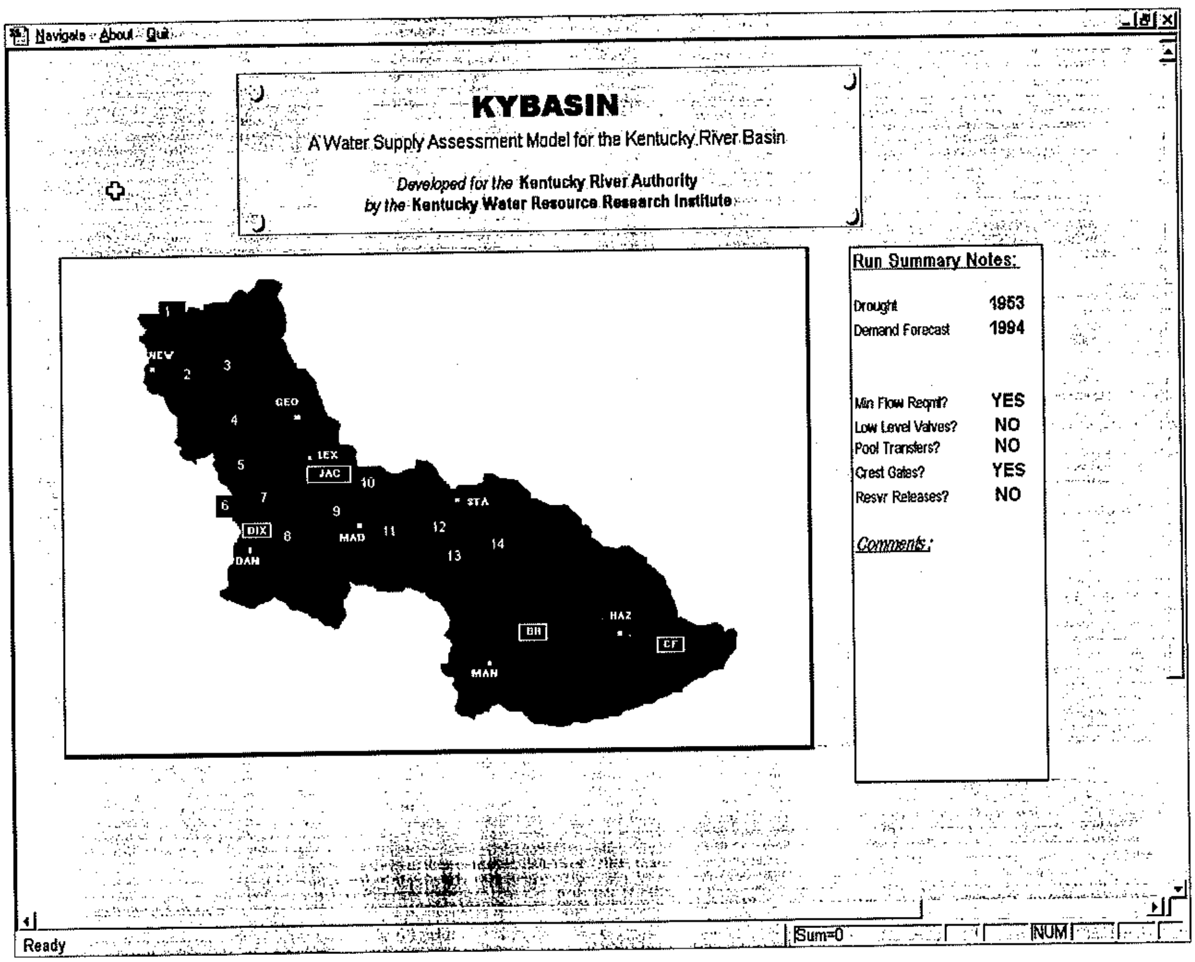
5. Repeat if necessary.

Once the output has been reviewed, subsequent simulations can be performed by repeating steps 2 - 4.

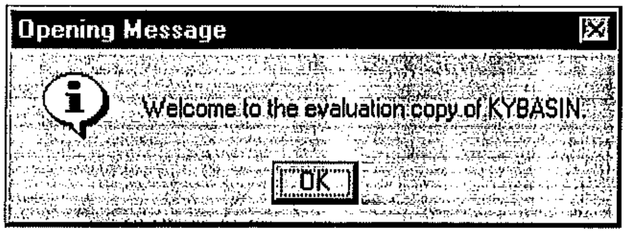
Visual Tour of KYBASIN

The following pages provide an illustrated look at the layout of the KYBASIN model. Illustrations of the menu systems, input screens, and pop-up windows are included to familiarize the user with the KYBASIN environment. A brief textual description appears below each illustration.

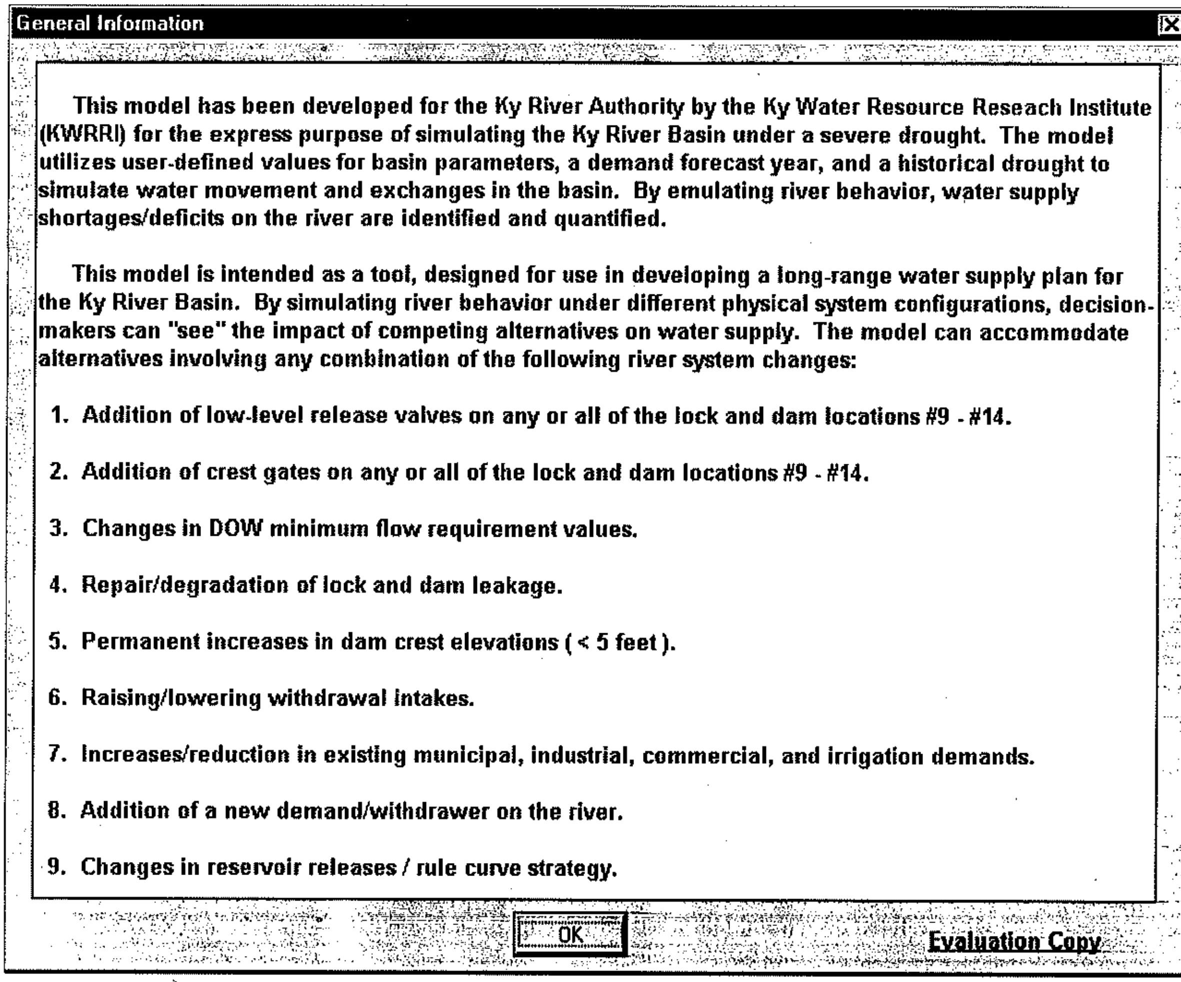
Opening Screen Items



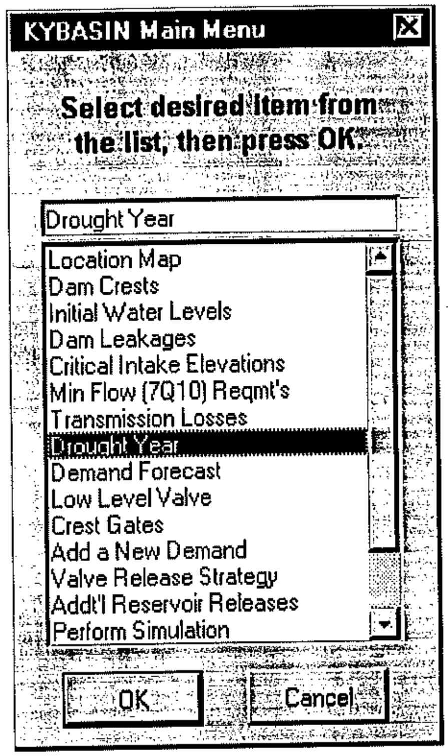
1. *Opening Screen.* The Opening Screen is automatically displayed when the user opens the KYBASIN model. Clicking on the basin map in the center of the opening screen activates the Main Menu (4). A summary of current values for user parameters is given in the Run Summary Notes area located to the right of the basin map.



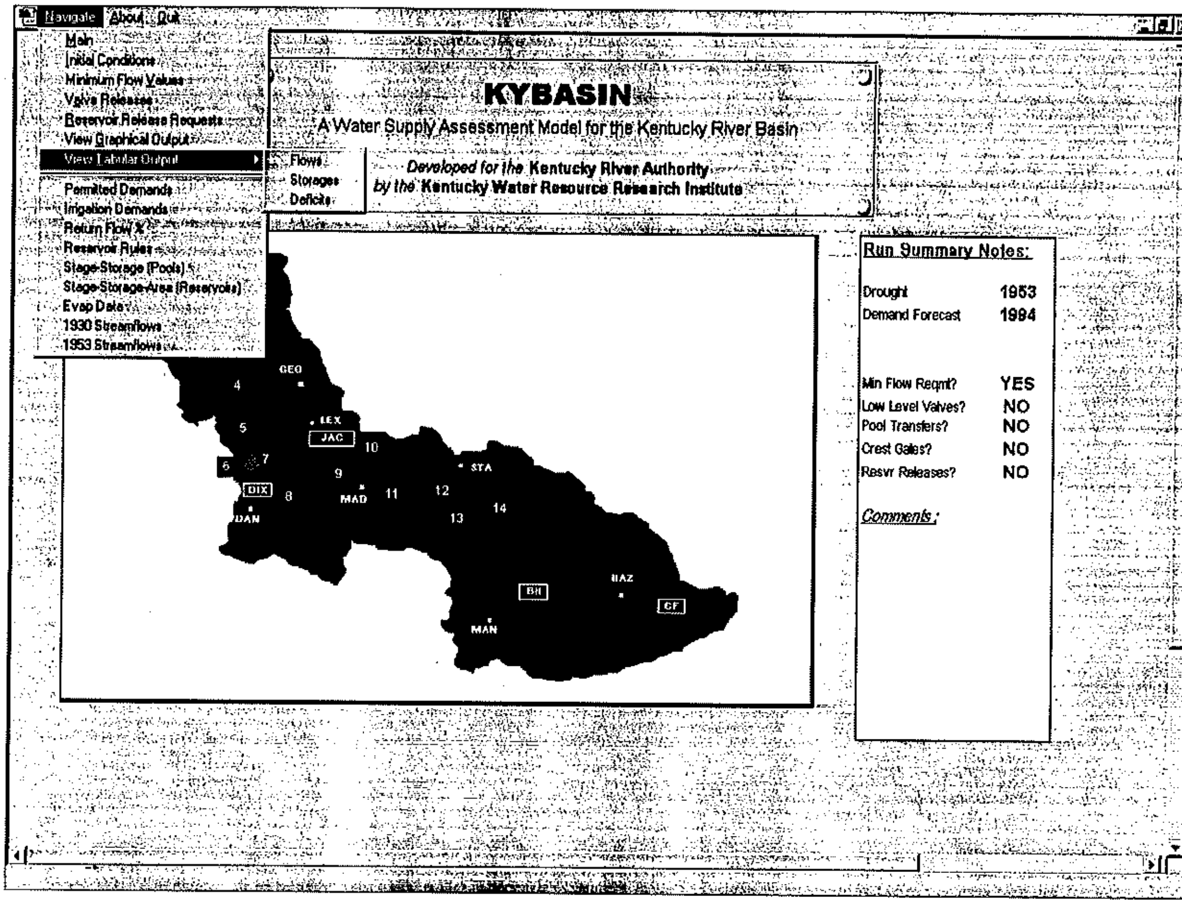
2. *Opening Message Box.* The Opening Message Box appears automatically when the user opens the KYBASIN model. Clicking the OK button will dismiss the box and allow the model to continue to load.



3. *General Information Box.* The General Information Box appears automatically after the Opening Message Box is dismissed. The General Information Box provides a brief overview of the model and its capabilities. Clicking the OK button will dismiss the box and allow the model to continue to load. Both the Opening Message Box and the General Information Box may be viewed again by selecting the appropriate item from the About menu in the menubar located at the top of the screen.

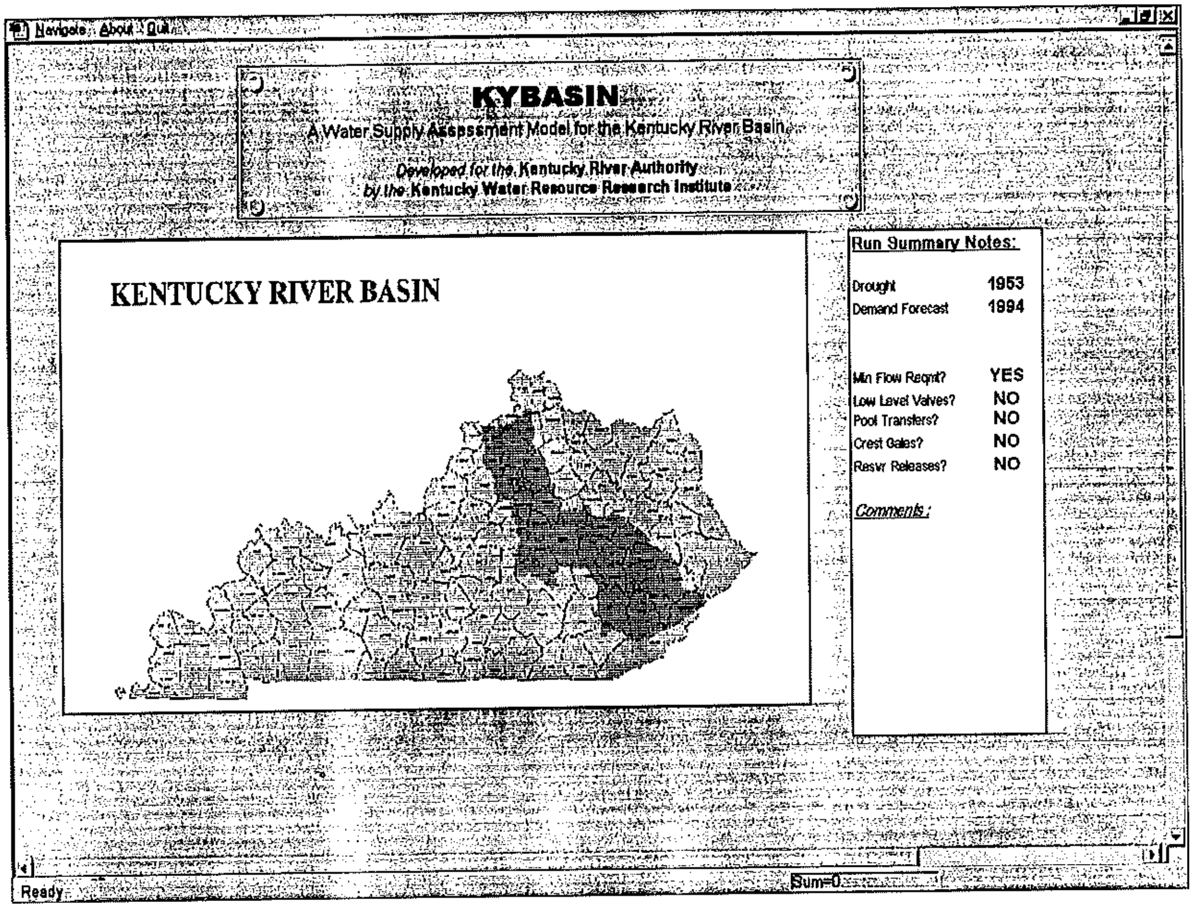


4. *Main Menu.* The Main Menu may be viewed by clicking the right mouse button on the basin map located in the Opening Screen. Items in the Main Menu may be selected by right clicking the item in the list and then pressing the OK button to confirm the selection. The Main Menu is one of KYBASIN's two menu systems. The menu items in the Main Menu contain links to the most commonly used inputs that are needed when performing a simulation. Selecting an item in the Main Menu allows the user to edit the associated parameter (e.g. initial water levels, dam leakages, etc.) or perform the listed action (e.g. perform the simulation, quit the program, etc.). The Main Menu may only be activated from the basin map on the *Opening Screen.*



5. *The Menubar.* The Menubar is located at the top of the screen and is available from all user input screens. The Menubar contains three menu items: Navigate, About, and Quit. Each menu item represents a separate menu available to the user. The Navigate menu provides the user with links to user input tables. Some of the items listed in the Navigate menu are also listed on the Main Menu. The About menu allows the user to display the Opening Message and General Information boxes. The Quit menu may be used to exit KYBASIN.

Main Menu Items



6. *Location Map.* The location map is the first item in the Main Menu. Selecting it will display a map of Kentucky with the Kentucky River Basin highlighted. Clicking anywhere on the location map will restore the detailed basin map.

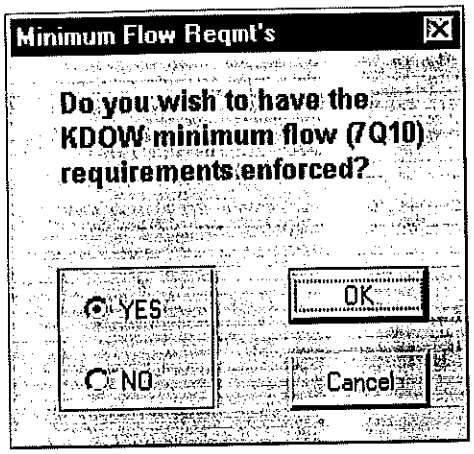
Navigate About... Quit

Initial Conditions

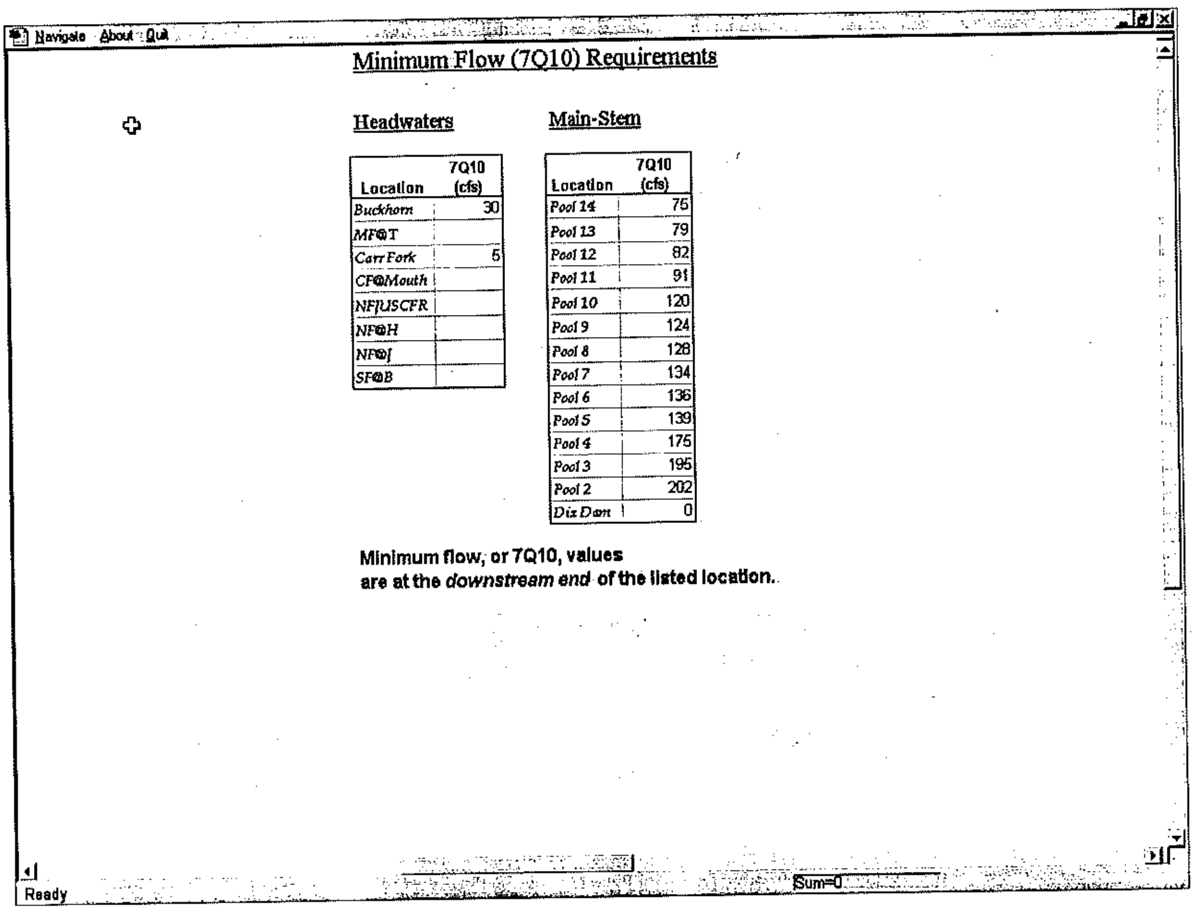
Impoundment	Initial Water Level (ft)	Dam Crest Elev (ft)	Dam Leakage (cfs)	Critical Intake Elev (ft)
Pool 14	635.4	634.4	50	630
Pool 13	618.9	617.9	50	607.9
Pool 12	601.1	600.1	50	590.1
Pool 11	584.1	583.1	50	575.7
Pool 10	566.7	565.7	50	557.1
Pool 9	549.6	548.6	50	540
Pool 8	532.24	531.24	50	529.1
Pool 7	514.1	513.1	50	502.8
Pool 6	498.2	497.2	50	493
Pool 5	484.54	483.54	50	479
Pool 4	469.53	468.53	50	458.55
Pool 3	455.33	454.33	50	450.33
Pool 2	442.02	441.02	50	431.02
Dix Dam	720		20	655
Jacobson	967.2		0	587
Buckhorn	757		0	715
Carr Fork	1017		0	960

Ready Sum=0 CAPS NUM

7. *Initial Conditions Screen.* Selecting dam crests, initial water levels, dam leakages, or critical intake elevations from the Main Menu will display the Initial Conditions Screen. The user may specify values for these parameters by editing the default values in the table. Selecting *Main* from the Navigate menu on the menubar will return the user to the opening screen.



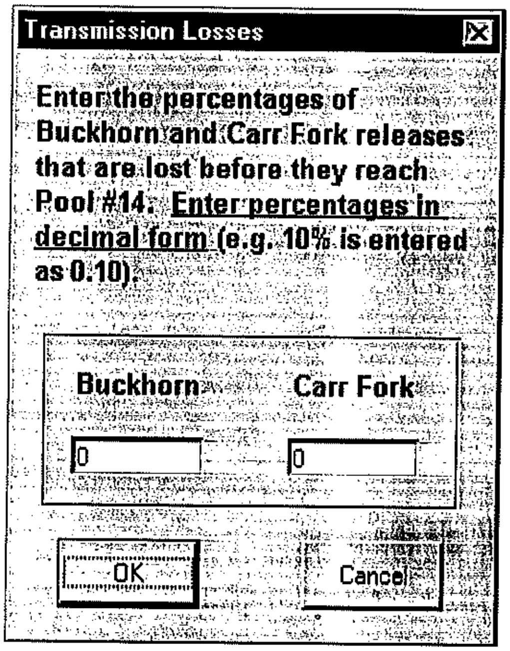
8. *Minimum Flow Reqmt's Box.* The Minimum Flow Reqmt's box is a pop-up window that is displayed when the user selects *Min Flow Reqmt's* from the Main Menu. If the user indicates a "yes" response, then the Minimum Flow Requirements Screen is displayed. A "no" response returns the user to the Opening Screen.



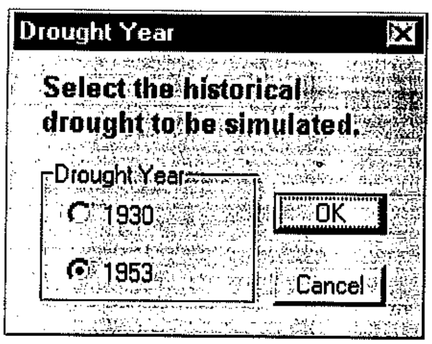
Location	7Q10 (cfs)
Buckhorn	30
MF@T	
Carr Fork	5
CF@Mouth	
NFJUSCFR	
NF@H	
NF@J	
SF@B	

Location	7Q10 (cfs)
Pool 14	75
Pool 13	79
Pool 12	82
Pool 11	91
Pool 10	120
Pool 9	124
Pool 8	128
Pool 7	134
Pool 6	136
Pool 5	139
Pool 4	175
Pool 3	195
Pool 2	202
Dix Dam	0

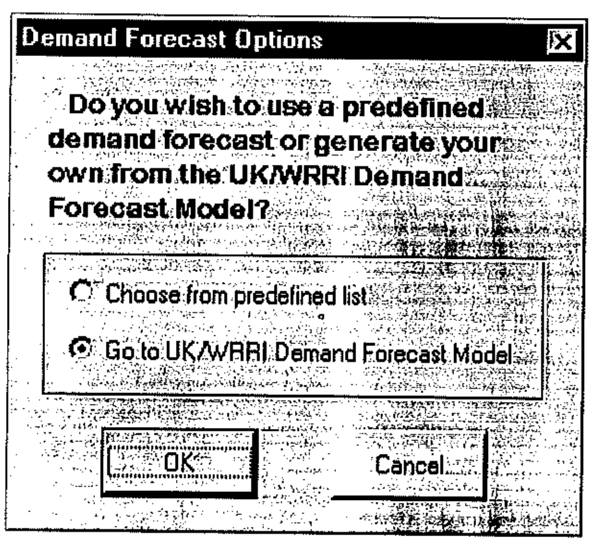
9. *Minimum Flow Requirements Screen.* The Minimum Flow Requirements Screen allows the user to specify a minimum flow requirements at any of the locations listed in the table. If minimum flow requirements are not enforced (see #8), then values in the table will be ignored.



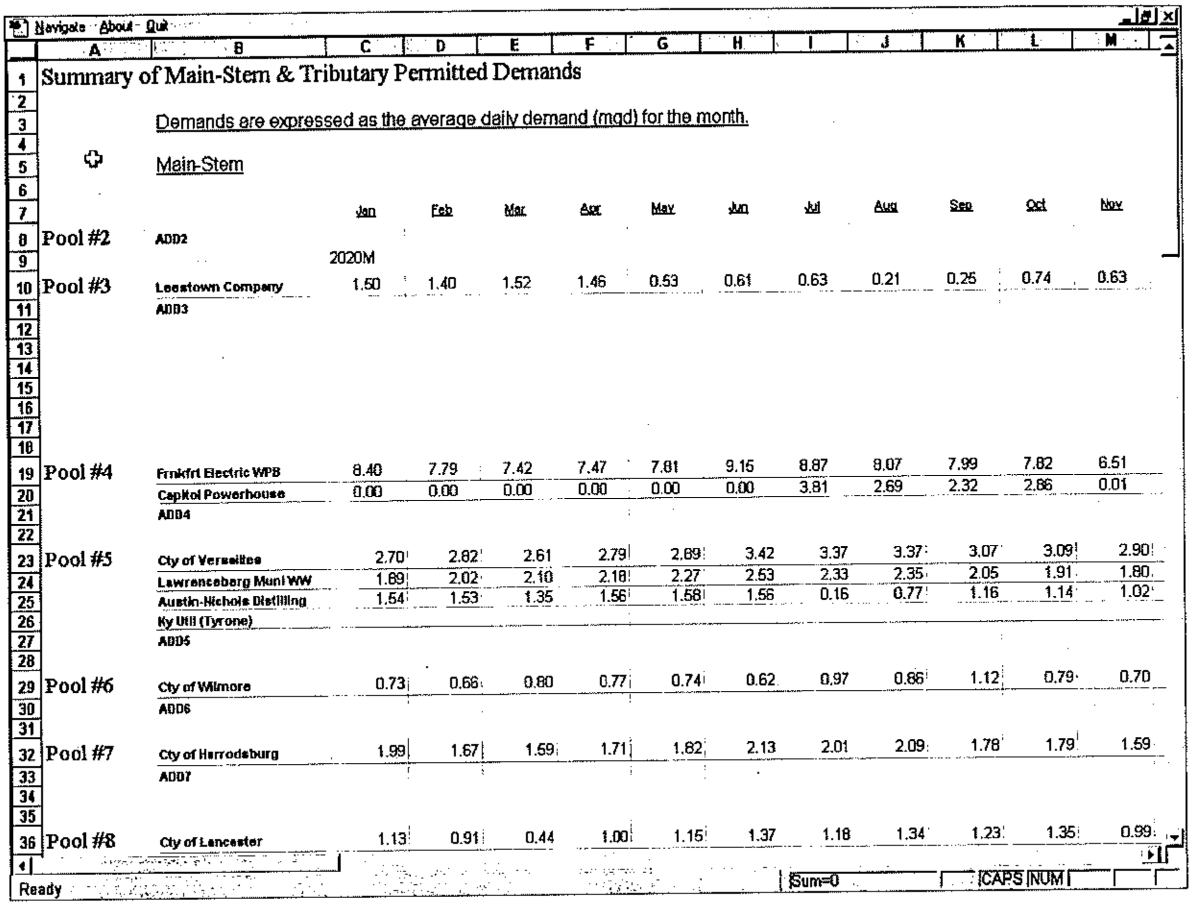
10. *Transmission Losses Box.* Transmission losses for releases from Buckhorn and Carr Fork reservoirs are identified in the Transmission Losses Box. This pop-up window is displayed when the user selects *Transmission Losses* from the Main Menu.



11. *Drought Year Box.* The historical drought conditions to be considered in the simulation is selected in the Drought Year Box. Selecting *Drought Year* from the Main Menu will display this pop-up window.



12. *Demand Forecast Options Box.* The Demand Forecast Options Box is displayed when the user selects *Demand Forecast* from the Main Menu. The user may either elect to load a redefined demand forecast or create their own with the UK/KWRRI Demand Forecast Model. Both choices provide easy methods to load the desired municipal demand forecast.



Navigate About Quit

Summary of Main-Stem & Tributary Permitted Demands

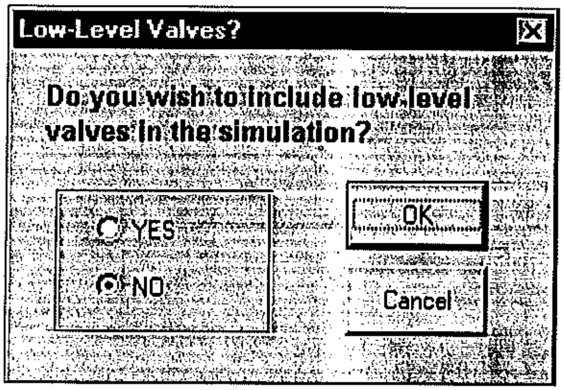
Demands are expressed as the average daily demand (mgd) for the month.

Main-Stem

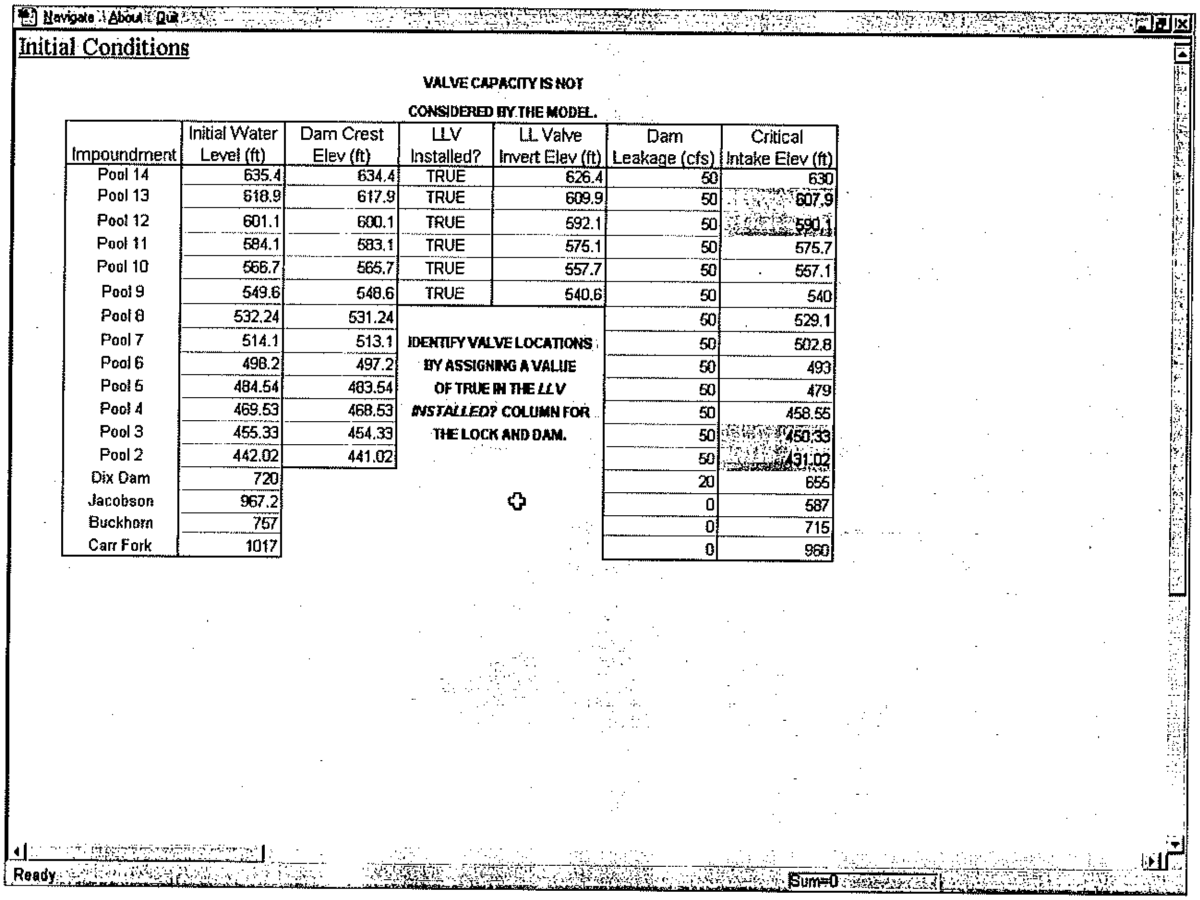
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Pool #2	ADD2											
		2020M										
Pool #3	Leestown Company	1.50	1.40	1.52	1.46	0.53	0.61	0.63	0.21	0.25	0.74	0.63
	ADD3											
Pool #4	Frnkfrt Electric WPB	8.40	7.79	7.42	7.47	7.81	9.15	8.87	8.07	7.99	7.82	6.51
	Capitol Powerhouse	0.00	0.00	0.00	0.00	0.00	0.00	3.81	2.69	2.32	2.86	0.01
	ADD4											
Pool #5	City of Versailles	2.70	2.82	2.61	2.79	2.69	3.42	3.37	3.37	3.07	3.09	2.90
	Lawrenceburg Muni WW	1.69	2.02	2.10	2.18	2.27	2.53	2.33	2.35	2.05	1.91	1.80
	Austin-Nichols Distilling	1.54	1.53	1.35	1.56	1.58	1.56	0.16	0.77	1.16	1.14	1.02
	Ky Util (Tyrone)											
	ADD5											
Pool #6	City of Wilmore	0.73	0.66	0.80	0.77	0.74	0.62	0.97	0.86	1.12	0.79	0.70
	ADD6											
Pool #7	City of Harrodsburg	1.99	1.67	1.59	1.71	1.82	2.13	2.01	2.09	1.78	1.79	1.59
	ADD7											
Pool #8	City of Lancaster	1.13	0.91	0.44	1.00	1.15	1.37	1.18	1.34	1.23	1.35	0.99

Ready Sum=0 CAPS NUM

13. *Municipal Demand Database Screen.* Municipal demand forecasts for all permitted surface water withdrawals are listed in the Municipal Demand Database Screen. Individual demands may be modified by editing the appropriate values in the table. Global changes are made by selecting *Demand Forecast* from the Main Menu.

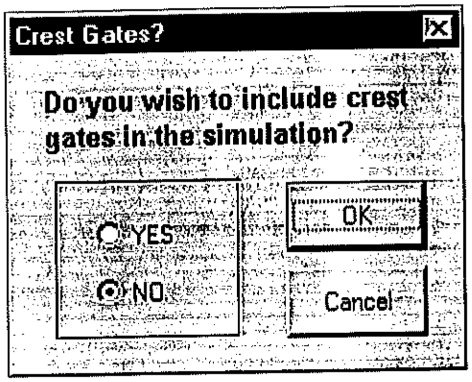


14. *Low-Level Valves Box.* The Low-Level Valves pop-up window is displayed by selecting it from the Main Menu. A "yes" response will inform the model to consider low-level valves in the analysis at the locations listed in the Initial Conditions Screen (see #15). A "no" response will remove the low-level valve columns from the Initial Conditions Screen and return to the Opening Screen.

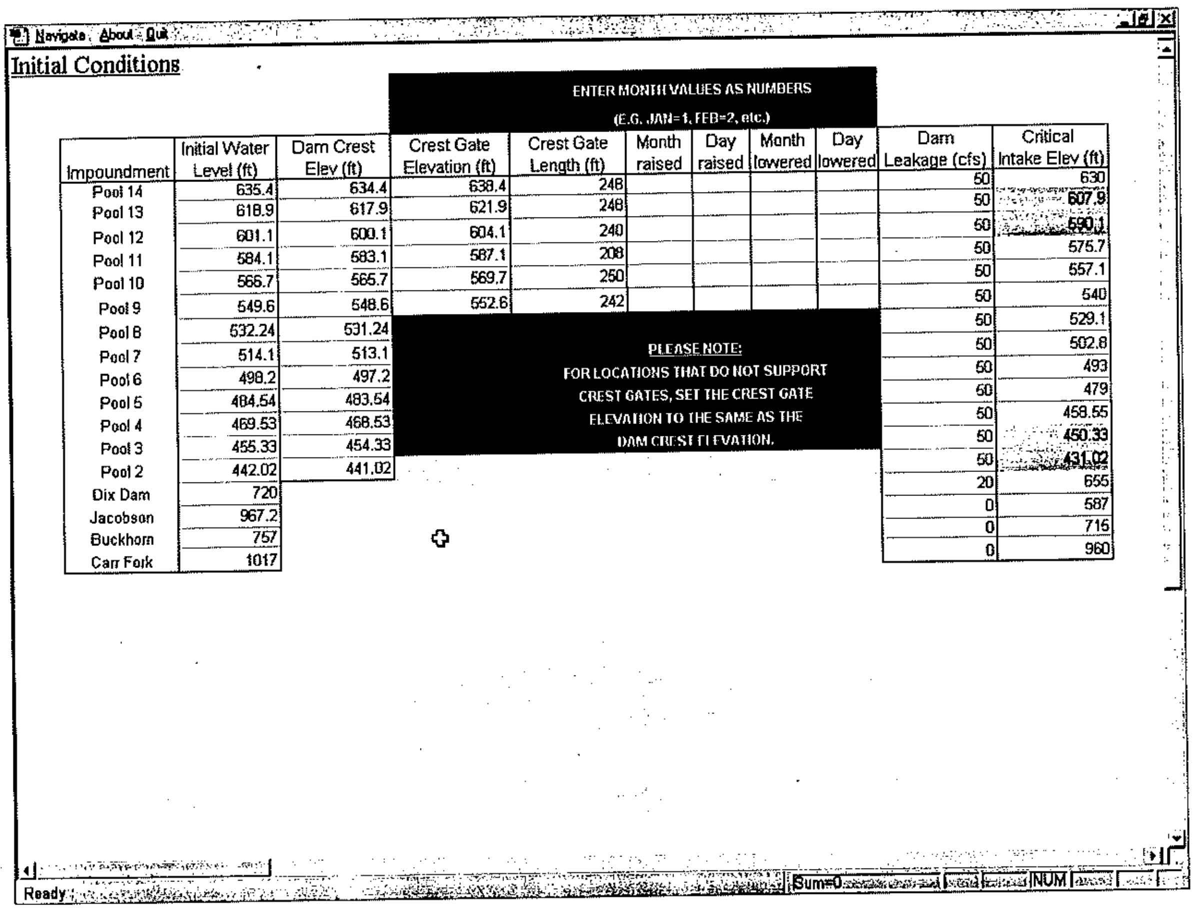


Impoundment	Initial Water Level (ft)	Dam Crest Elev (ft)	LLV Installed?	LL Valve Invert Elev (ft)	Dam Leakage (cfs)	Critical Intake Elev (ft)
Pool 14	635.4	634.4	TRUE	626.4	50	630
Pool 13	618.9	617.9	TRUE	609.9	50	607.9
Pool 12	601.1	600.1	TRUE	592.1	50	590.1
Pool 11	584.1	583.1	TRUE	575.1	50	575.7
Pool 10	566.7	565.7	TRUE	557.7	50	557.1
Pool 9	549.6	548.6	TRUE	540.6	50	540
Pool 8	532.24	531.24			50	529.1
Pool 7	514.1	513.1			50	502.8
Pool 6	498.2	497.2			50	493
Pool 5	484.54	483.54			50	479
Pool 4	469.53	468.53			50	458.55
Pool 3	455.33	454.33			50	450.33
Pool 2	442.02	441.02			50	431.02
Dix Dam	720				20	655
Jacobson	967.2				0	587
Buckhorn	757				0	715
Carr Fork	1017				0	960

15. *Initial Conditions Screen (with Low Level Valves).* If the user elects to consider low-level valves, the table in the Initial Conditions Screen will appear with the two additional columns illustrated in the picture. These two columns indicate whether a lock is equipped with a valve and its depth. As with all input screens, the user may select *Main* from the Navigate menu on the menubar to return to the Opening Screen.



16. *Crest Gates Box.* The Crest Gates pop-up window is displayed when the user selects *Crest Gates* from the Main Menu. A "yes" response will inform the model to consider crest gates in the analysis at the location identified in the Initial Conditions Screen (see #17). A "no" response will remove the crest gate columns from the Initial Conditions Screen and return to the Opening Screen.


Navigate About Quit

Initial Conditions

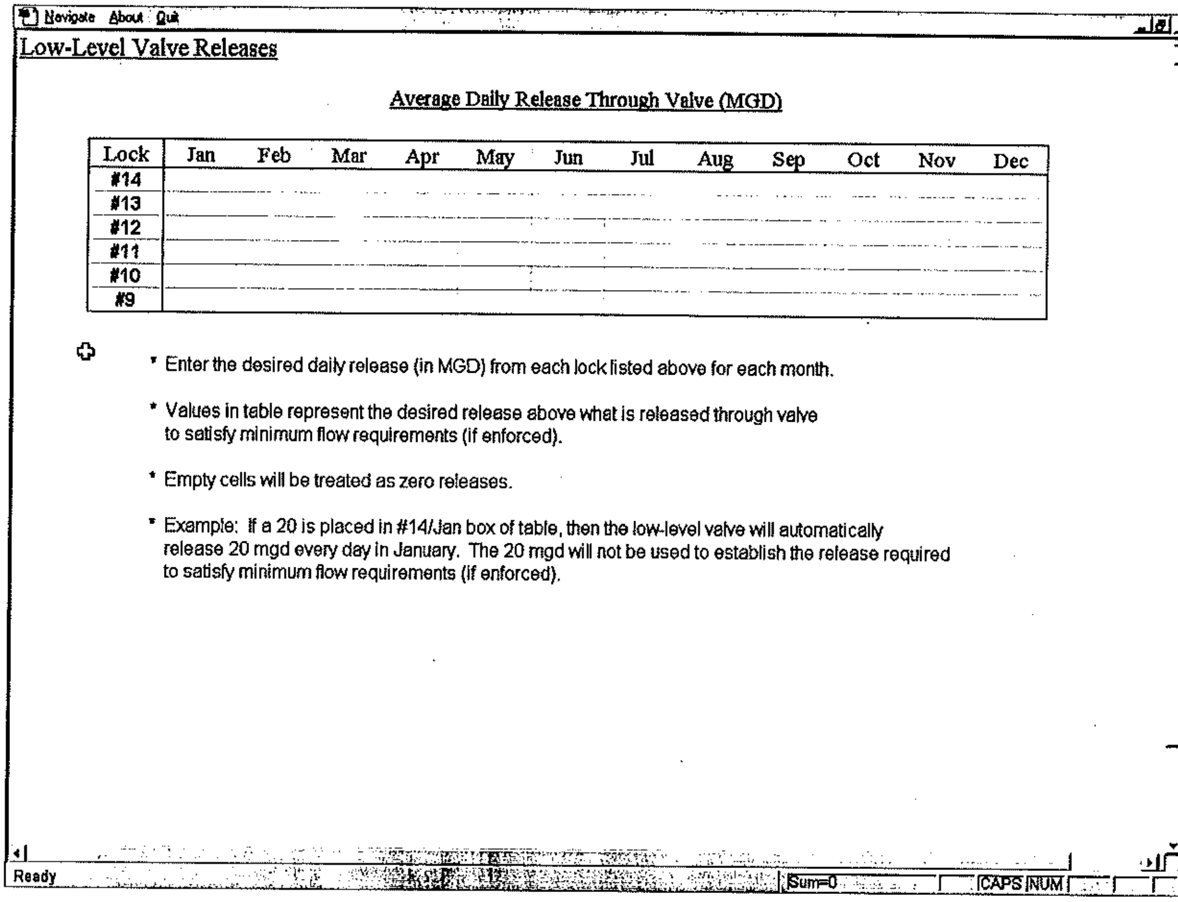
ENTER MONTH VALUES AS NUMBERS (E.G. JAN=1, FEB=2, etc.)

Impoundment	Initial Water Level (ft)	Dam Crest Elev (ft)	Crest Gate Elevation (ft)	Crest Gate Length (ft)	Month raised	Day raised	Month lowered	Day lowered	Dam Leakage (cfs)	Critical Intake Elev (ft)
Pool 14	635.4	634.4	638.4	248					50	630
Pool 13	618.9	617.9	621.9	248					50	607.9
Pool 12	601.1	600.1	604.1	240					50	590.1
Pool 11	584.1	583.1	587.1	208					50	575.7
Pool 10	566.7	565.7	569.7	250					50	557.1
Pool 9	549.6	548.6	552.6	242					50	540
Pool 8	532.24	531.24							50	529.1
Pool 7	514.1	513.1							50	502.8
Pool 6	498.2	497.2							50	493
Pool 5	484.54	483.54							50	479
Pool 4	469.53	468.53							50	458.55
Pool 3	455.33	454.33							50	450.33
Pool 2	442.02	441.02							50	431.02
Dix Dam	720								20	655
Jacobson	967.2								0	587
Buckhorn	757								0	716
Carr Fork	1017								0	960

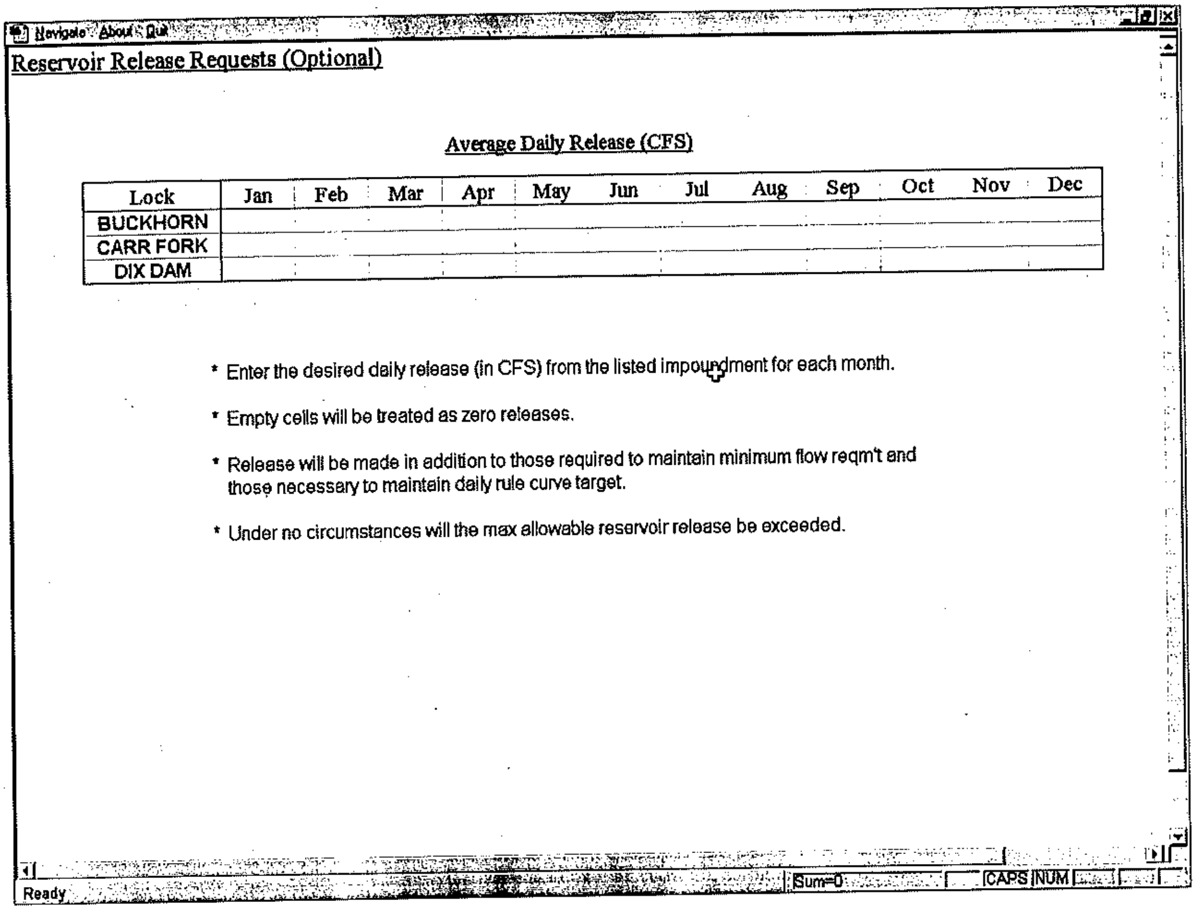
PLEASE NOTE:
FOR LOCATIONS THAT DO NOT SUPPORT CREST GATES, SET THE CREST GATE ELEVATION TO THE SAME AS THE DAM CREST ELEVATION.

Ready Sum=0 NUM

17. *Initial Conditions Screen (with Crest Gates).* If the user elects to consider crest gates in the analysis, the table in the Initial Conditions Screen will appear with the six additional columns illustrated in the picture. These columns indicate where crest gates are located, their size, and how they will be operated. Setting the crest gate elevation equal to the dam crest elevation in the table assumes that no crest gate is installed at the dam location.

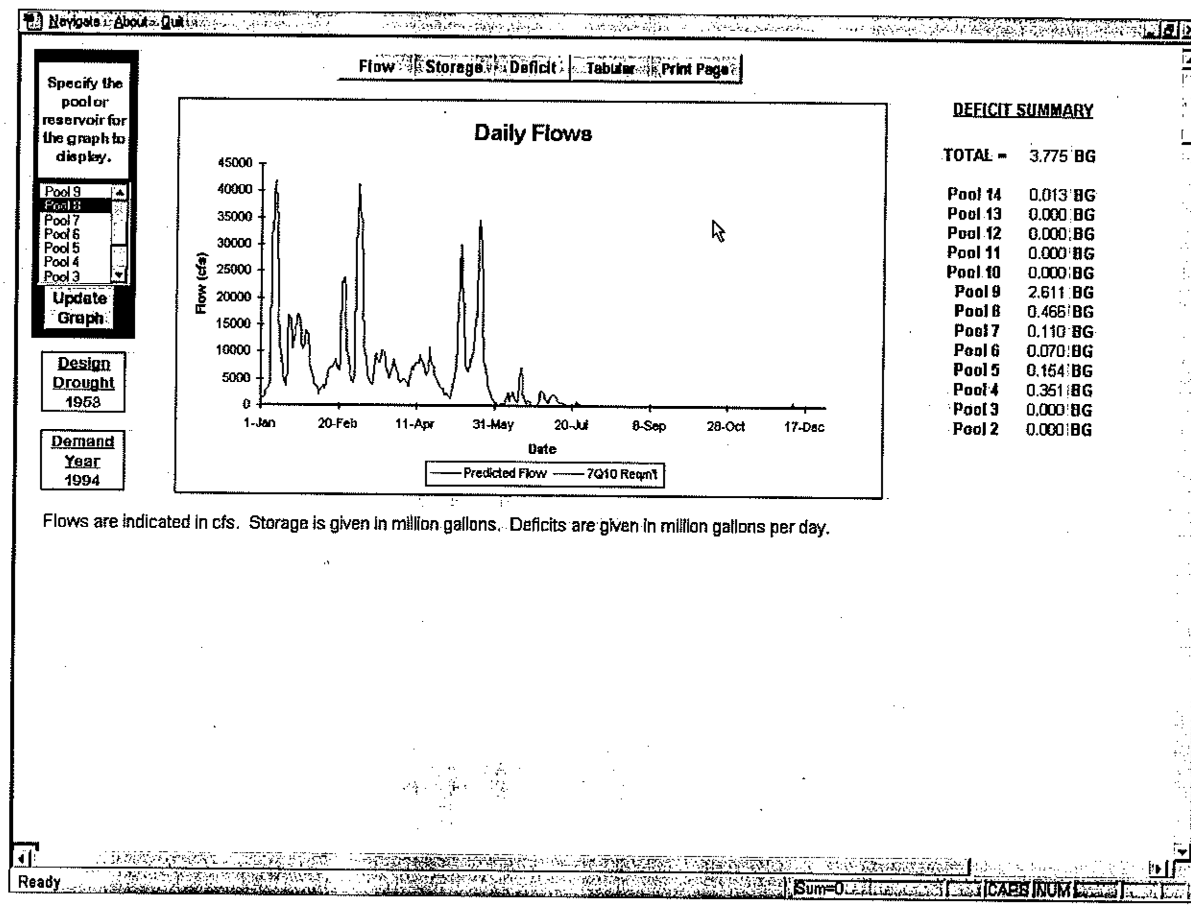


18. *Low-Level Valve Releases Screen.* If low-level valves are considered in the analysis, the values in the table on this screen are used to dictate low-level valve operation. Values in the table reflect the valve release setting at the listed location. Release requests in the table are ignored if valves are not being considered or no valve exists at the dam location. This screen is accessed by selecting *Valve Release Strategy* from the Main Menu.

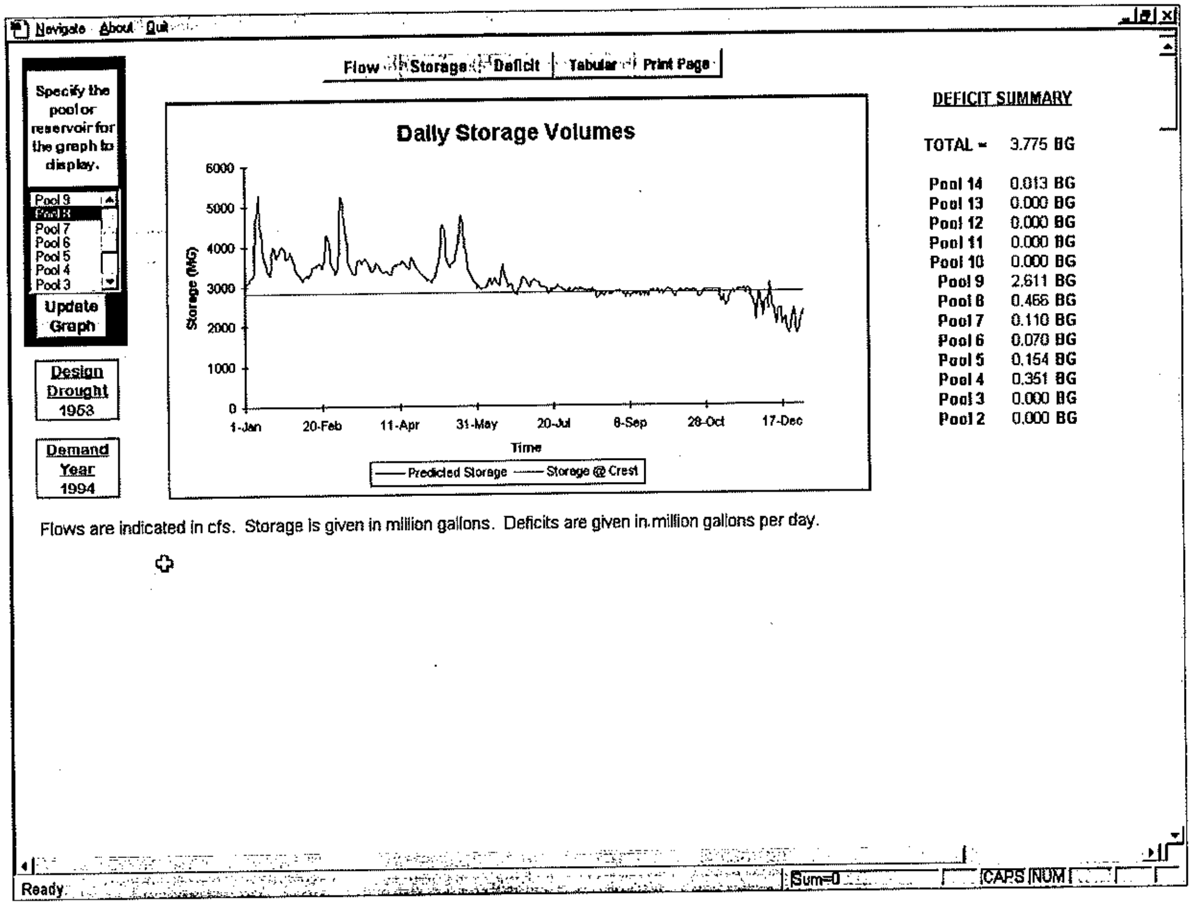


19. *Reservoir Release Requests Screen.* This screen is accessed from the Main Menu by selecting *Addt'l Reservoir Releases.* Values in table reflect release requests from the listed reservoir that are above and beyond those made to maintain the rule curve and satisfy DOW minimum release requirements. Release requests are honored provided the maximum reservoir release limit is not exceeded.

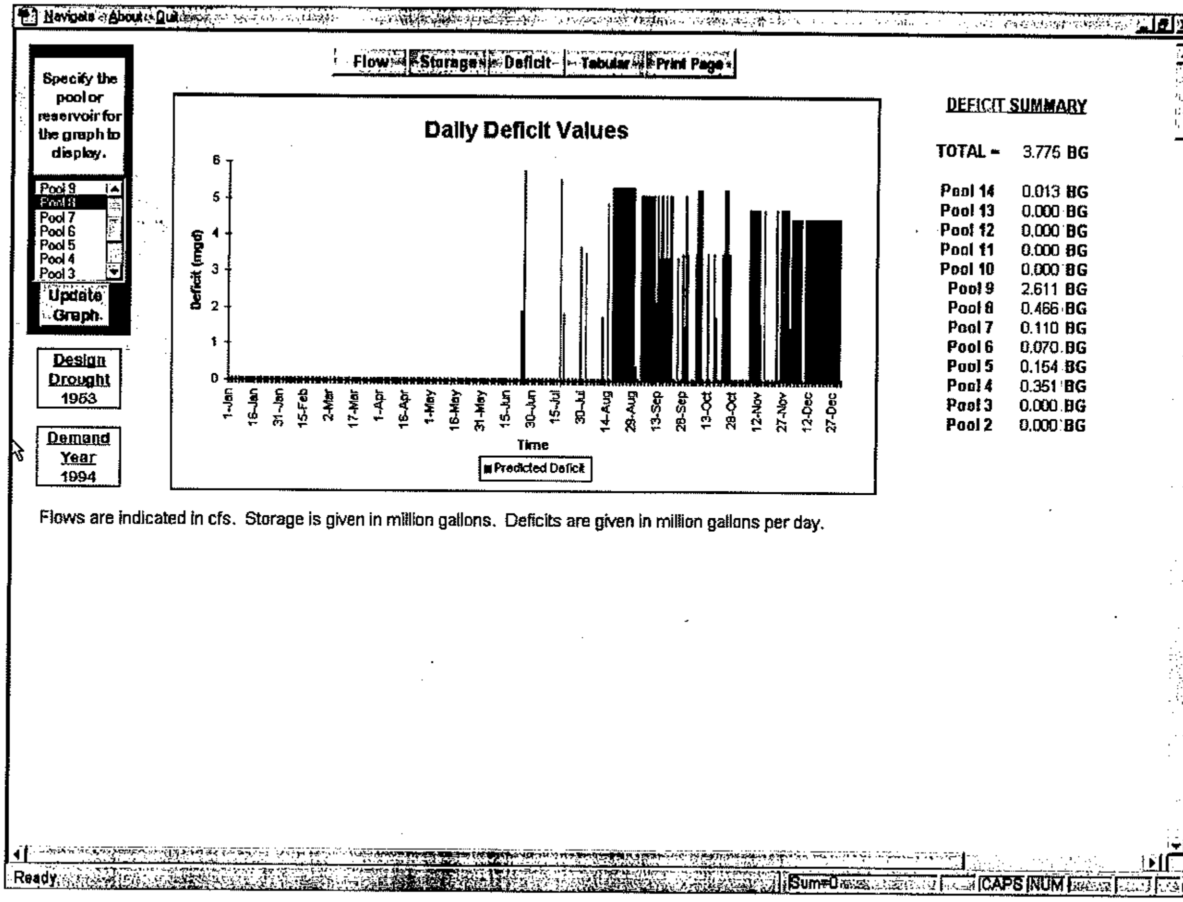
20-2. The Output Screens illustrated in #20 - #22 may be accessed from the Main Menu or from the Navigate menu in the menubar. The buttons located above the output graph allow the user to select the desired output parameter. The output parameter is displayed for the pool/reservoir that is selected in the listbox to the left of the output graph. When a new pool/reservoir is selected, the user must press the Update Graph button to display the new output. A summary of the municipal demand deficits are listed in the table to the right of the output graph. The current design drought and demand year are displayed in the lower left of the Output Screen. The output displayed on the Output Screen reflects the input data at the time of the last simulation. Any changes in the input data are not reflected in the Output Screen until the basin is re-simulated.



20. *Output Screen (Daily Flows).* Displays the daily flow traces at all mainstem dam locations and major reservoirs for the entire 12-month analysis period.



21. *Output Screen (Daily Storages).* Displays the daily storages for all mainstem pools and major reservoirs for the entire 12-month analysis period.



22. *Output Screen (Daily Deficits).* Displays the daily municipal demand deficits in all mainstem pools.

Tabulated Daily Output Values

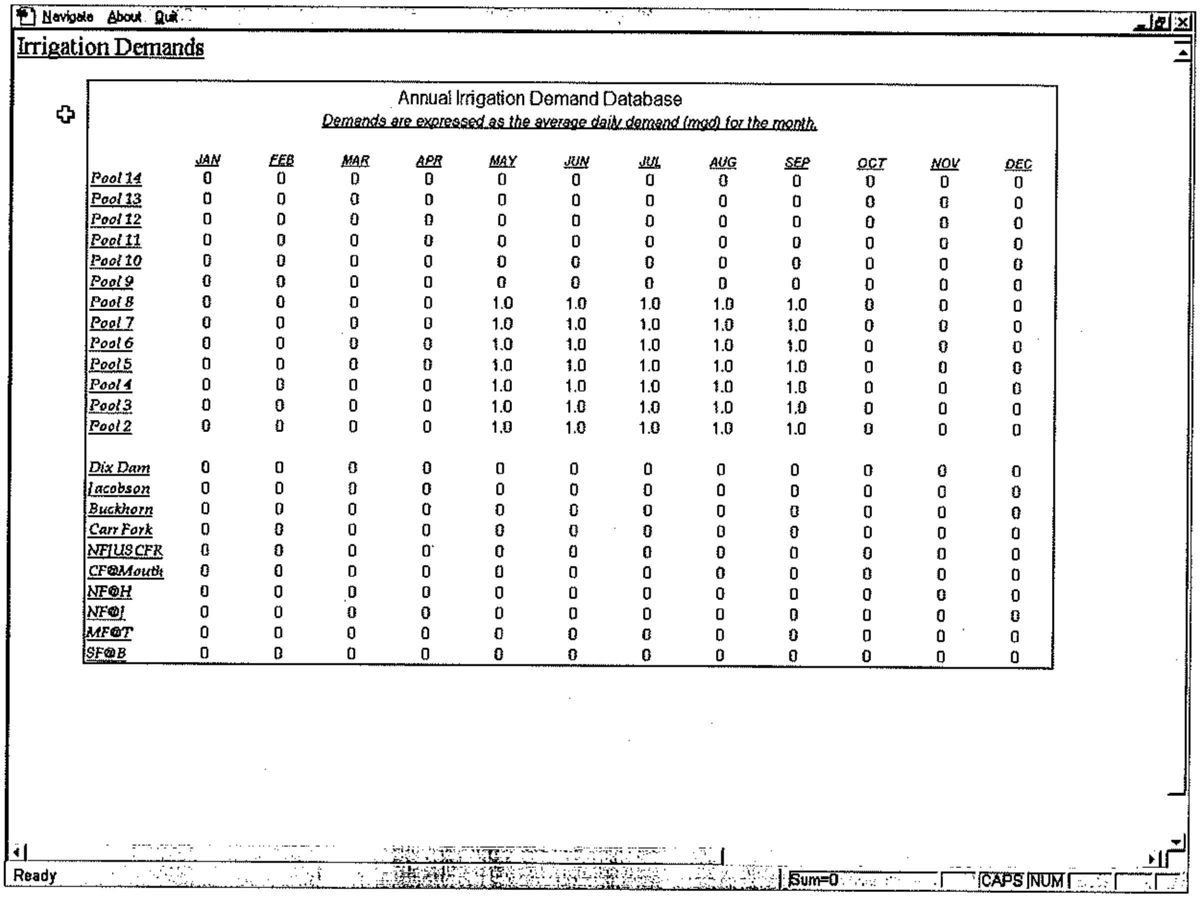
This data is static; it is written here immediately after the analysis is performed. Output graphics access this data.

Flow Values (@ End of Day)

	Reach Index Number 1	2	3	4	5	6	7	8	9	10	11	12	13	
Date	Pool 14	Pool 13	Pool 12	Pool 11	Pool 10	Pool 9	Pool 8	Pool 7	Pool 6	Pool 5	Pool 4	Pool 3	Pool 2	Dix Dai
1-Jan	843.76	929.63	1010.53	1221.91	1691.50	1931.60	2669.43	2938.92	2829.09	3087.62	3465.53	4176.64	4399.01	18
2-Jan	1288.83	1321.63	1391.70	1436.21	1570.45	1364.05	1210.48	1340.23	1458.33	1647.66	1962.16	2597.29	2837.11	61
3-Jan	1617.36	1666.89	1759.46	1879.41	2144.21	1908.69	1687.45	1603.93	1474.21	1808.57	2330.26	2978.83	3206.04	97
4-Jan	2433.52	2444.10	2604.76	2747.87	2938.71	2559.84	2168.54	2047.57	1880.77	2018.75	2275.17	3081.88	3311.64	162
5-Jan	2353.89	2458.40	2545.84	2775.93	3345.80	3198.79	3039.47	3091.23	2940.99	2853.80	2756.63	3312.27	3433.55	173
6-Jan	2161.67	2271.99	2353.66	2575.66	3182.60	3203.29	3360.42	3672.06	3713.79	3491.96	3170.47	4432.40	4774.02	148
7-Jan	9840.72	8586.29	9366.40	10167.44	9530.22	7882.44	5889.40	5438.07	4434.64	3833.60	3138.96	4197.23	4537.45	1504
8-Jan	22266.69	20743.55	21579.80	24974.75	30498.82	29637.40	27799.43	26663.38	23472.85	21833.78	19835.75	20537.41	20109.92	1504
9-Jan	28822.35	28641.52	29148.28	31745.38	37675.05	38155.40	37147.64	36630.96	35829.46	34973.05	33665.97	37445.43	38574.95	1504
10-Jan	20276.76	24037.10	25251.43	28731.99	38740.69	40278.07	41644.20	43512.70	43390.05	43757.06	43228.03	46393.75	47276.69	1504
11-Jan	12101.57	14707.79	16051.95	18195.10	25117.86	27378.89	31340.51	38537.64	41108.90	41434.20	43550.33	47849.45	49058.93	1504
12-Jan	8715.06	9677.03	10304.41	11180.86	14059.10	16215.72	20364.17	24421.00	25831.98	27153.42	29676.15	36635.46	39359.10	1504
13-Jan	5503.58	6321.26	6482.32	7146.45	9550.71	10437.32	12261.19	15464.09	15987.30	16661.58	17608.93	20403.12	21181.33	1504
14-Jan	3960.74	4467.69	4711.34	5366.63	7602.55	7870.17	8522.70	10700.72	10929.60	11285.46	11892.19	13021.05	13663.70	1504
15-Jan	3192.70	3471.05	3629.04	4057.60	5383.93	5540.84	5833.03	7745.28	8015.22	8328.44	8787.32	9865.06	10258.43	1504
16-Jan	2559.85	2777.02	2888.75	3253.64	4338.94	4544.38	4983.07	6891.84	7109.92	7355.45	7699.18	8387.94	8633.58	1504
17-Jan	2420.44	2570.54	2706.19	3020.72	3868.45	3795.07	3759.96	5338.73	5378.55	5863.91	6541.74	9385.76	10279.94	1504
18-Jan	9814.47	8660.35	9457.48	10355.82	10140.10	9555.04	9673.49	10482.75	9884.47	9653.42	9590.03	10804.64	11093.28	1504
19-Jan	11971.49	12122.38	12379.35	13791.51	16432.87	16288.30	16532.03	17913.59	17326.48	16654.38	15862.46	15796.64	15569.84	1504
20-Jan	7801.79	9034.53	9160.15	10056.71	13390.45	13992.57	15374.21	18141.84	18991.87	19206.60	19305.77	19492.07	19685.58	1504
21-Jan	6831.16	7173.83	7499.49	7876.01	9318.57	9931.61	11107.49	13576.84	14180.97	14504.81	14880.28	16111.94	16517.51	1504
22-Jan	13451.89	12092.15	12508.70	12748.81	11388.22	10929.64	10703.40	11617.21	11242.23	11148.84	11193.32	12241.98	12648.67	1504
23-Jan	12762.03	13280.78	13157.62	13892.11	15619.48	15043.43	14419.11	15156.03	14570.68	13819.05	12883.64	12258.81	11920.45	1051
24-Jan	8730.05	9947.47	10192.19	11041.68	14297.84	14662.72	15742.02	18348.14	19111.13	19395.52	19502.90	18586.89	18355.20	1504
25-Jan	9683.30	9975.05	10724.55	11905.37	14703.33	15421.91	17008.35	19367.53	19722.39	20071.37	20539.48	22211.59	22446.06	1504
26-Jan	9186.23	9713.87	10085.41	11115.32	13635.70	14226.91	15664.14	18130.23	18505.59	18690.86	19028.13	20593.34	21193.75	1504
27-Jan	6764.85	7507.84	7694.83	8373.94	10704.29	11202.62	12253.83	14763.21	15252.49	15413.90	15611.68	16751.15	17224.72	1504
28-Jan	6432.78	6800.26	7186.55	7899.50	9861.09	10074.80	10596.88	12536.07	12672.26	13257.52	13992.24	16916.87	17842.47	1504
29-Jan	11637.56	10717.81	11218.24	11781.88	11682.44	11444.36	11486.98	12615.42	12384.37	12467.40	12837.18	14223.16	14797.88	1504
30-Jan	10290.27	10916.61	10877.18	11613.69	13538.62	13563.70	14012.69	15912.60	15919.90	15609.49	15235.56	15566.24	15530.61	1504
31-Jan	6776.31	7650.44	7734.54	8203.30	10429.22	11098.88	12397.42	14314.37	15101.89	15282.27	15356.73	16037.08	16330.72	722

23. *Tabular Output.* Tabular versions of the data presented in the Output Screens (#20 - #22) can be viewed by selecting the Tabular button located above the output graph on any of the Output Screens. Tabular data may also be accessed from the Navigate menu on the menubar. The user may have to use the horizontal and vertical scroll bars located at the bottom and right side of the screen to view portions of the output.

Menubar Items



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Pool 14	0	0	0	0	0	0	0	0	0	0	0	0
Pool 13	0	0	0	0	0	0	0	0	0	0	0	0
Pool 12	0	0	0	0	0	0	0	0	0	0	0	0
Pool 11	0	0	0	0	0	0	0	0	0	0	0	0
Pool 10	0	0	0	0	0	0	0	0	0	0	0	0
Pool 9	0	0	0	0	0	0	0	0	0	0	0	0
Pool 8	0	0	0	0	1.0	1.0	1.0	1.0	1.0	0	0	0
Pool 7	0	0	0	0	1.0	1.0	1.0	1.0	1.0	0	0	0
Pool 6	0	0	0	0	1.0	1.0	1.0	1.0	1.0	0	0	0
Pool 5	0	0	0	0	1.0	1.0	1.0	1.0	1.0	0	0	0
Pool 4	0	0	0	0	1.0	1.0	1.0	1.0	1.0	0	0	0
Pool 3	0	0	0	0	1.0	1.0	1.0	1.0	1.0	0	0	0
Pool 2	0	0	0	0	1.0	1.0	1.0	1.0	1.0	0	0	0
Dix Dam	0	0	0	0	0	0	0	0	0	0	0	0
Jacobson	0	0	0	0	0	0	0	0	0	0	0	0
Buckhorn	0	0	0	0	0	0	0	0	0	0	0	0
Carr Fork	0	0	0	0	0	0	0	0	0	0	0	0
NFJUSCFR	0	0	0	0	0	0	0	0	0	0	0	0
CF@Mouth	0	0	0	0	0	0	0	0	0	0	0	0
NF@H	0	0	0	0	0	0	0	0	0	0	0	0
NF@J	0	0	0	0	0	0	0	0	0	0	0	0
MF@T	0	0	0	0	0	0	0	0	0	0	0	0
SF@B	0	0	0	0	0	0	0	0	0	0	0	0

24. *Irrigation Demands Screen.* Irrigation demands for the river basin are located on the Irrigation Demands Screen. Values may entered directly into the table displayed in the picture. The Irrigation Demands Screen is accessed by selecting *Irrigation Demands* from the Navigate menu on the menubar.

Navigate About Quit

Return Flow Percentages for WWTP Dischargers in the Basin

Discharger	Dependent Withdrawer	Withdrawal Location	Discharge Location	Return Flow Percentages (return flow = monthly dmd x return flow percent JAN	FEB	MAR	APR	MAY	JUN	JUL	A
Frankfort STP	Frankfort	POOL 4	POOL 3	0.553	1.117	0.775	0.571	0.609	0.629	0.571	
Town Branch STP (Lex)	KAWC	POOL 9	POOL 3	0.474	0.613	0.528	0.449	0.383	0.235	0.407	
Midway STP	KAWC	POOL 9	POOL 3	0.0068	0.0059	0.005	0.00592	0.00367	0.00606	0.00232	0.
Stamping Ground STP	Stamping Grnd	Trib to POOL 3	POOL 3	0.81	0.81	0.522	0.49	0.283	0.654	0.672	
Georgetown STP #1	Georgetown Muni	Trib to POOL 3	POOL 3	0.64	0.992	0.851	0.573	0.635	0.503	0.621	
Georgetown STP #2	KAWC (Toyota)	POOL 9	POOL 3	0.0215	0.0258	0.0235	0.0228	0.0211	0.0164	0.0178	C
Versailles STP	KAWC/Versailles	POOL 9 & 5	POOL 4	0.03	0.044	0.047	0.025	0.019	0.022	0.033	
Wilmore STP	Wilmore	POOL 6	POOL 7	0.573	0.576	0.785	0.477	0.685	0.19	0.408	
West Hickman STP (Lex)	KAWC	POOL 9	POOL 7	0.321	0.478	0.404	0.267	0.246	0.156	0.496	
Nicholasville STP	Nicholasville	POOL 8	POOL 7	0.716	0.838	0.703	0.506	0.659	0.55	0.685	
Lancaster STP	Lancaster	POOL 8	POOL 7	0.3932	0.4004	0.4893	0.5186	0.2946	0.2016	0.3493	C
Berea STP	Berea	Trib to POOL 8 & 11	POOL 8	0.64	0.992	0.851	0.573	0.635	0.503	0.621	
Tates Creek STP (Rich)	Richmond	POOL 11	POOL 9	0.253	0.348	0.371	0.311	0.274	0.347	0.189	
Dreaming Creek STP (Rich)	Richmond	POOL 11	POOL 10	0.497	0.401	0.425	0.424	0.415	0.346	0.407	
Irvine STP	Irvine	POOL 11	POOL 11	0.5279	0.5358	0.5345	0.4917	0.5275	0.3233	0.3585	C
Beattyville STP	Beattyville	POOL 14	POOL 14	0.268	0.184	0.211	0.258	0.124	0.039	0.265	
Danville STP	Danville	H. LAKE	H. LAKE	0.609	1.165	0.965	0.575	0.591	0.396	0.544	

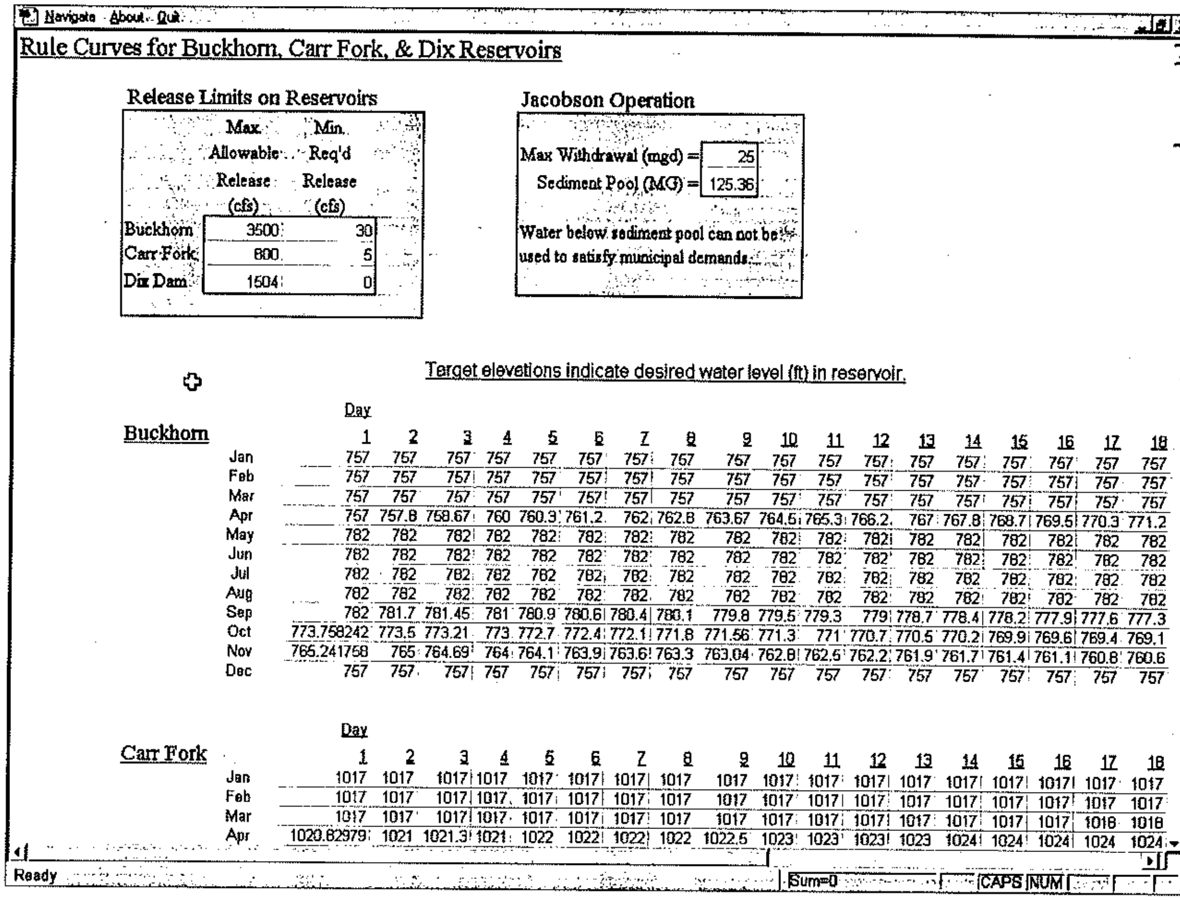
Return Flow Percentages for Headwater & Tributary Demands in the Basin

RF % is applied to sum of demands for each location. Return flows are assumed to return to the next downstream location (i.e. return flows from trib demands to pool #14 would first appear as inflow into the pool.)

		Return Flow Percentages (return flow = monthly dmd x return flow percentage) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	O
Tributaries to:	Pool 14	0.64	0.992	0.851	0.573	0.635	0.503	0.621	0.593	0.609	
	Pool 13	0.64	0.992	0.851	0.573	0.635	0.503	0.621	0.593	0.609	
	Pool 12	0.64	0.992	0.851	0.573	0.635	0.503	0.621	0.593	0.609	
	Pool 11	0.64	0.992	0.851	0.573	0.635	0.503	0.621	0.593	0.609	
	Pool 10	0.64	0.992	0.851	0.573	0.635	0.503	0.621	0.593	0.609	
	Pool 9	0.64	0.992	0.851	0.573	0.635	0.503	0.621	0.593	0.609	
	Pool 8	0.64	0.992	0.851	0.573	0.635	0.503	0.621	0.593	0.609	

Ready Sum=0 CAPS NUM

25. *Return Flow Screen.* The magnitude of wastewater treatment plant (WWTP) discharges are determined from the return flow percentages located in the table on this screen. All the major mainstem WWTPs are located in the upper table. Smaller tributary WWTPs are assigned the return flow percentages in the lower table for its associated parent pool. The Return Flow Screen is accessed by selecting *Return Flow %* from the Navigate menu on the menubar



Navigate About Quit

Rule Curves for Buckhorn, Carr Fork, & Dix Reservoirs

Release Limits on Reservoirs

	Max Allowable Release (cfs)	Min. Req'd Release (cfs)
Buckhorn	3500	30
Carr Fork	800	5
Dix Dam	1504	0

Jacobson Operation

Max Withdrawal (mgd) = 25

Sediment Pool (MG) = 125.36

Water below sediment pool can not be used to satisfy municipal demands.

Target elevations indicate desired water level (ft) in reservoir.

Buckhorn

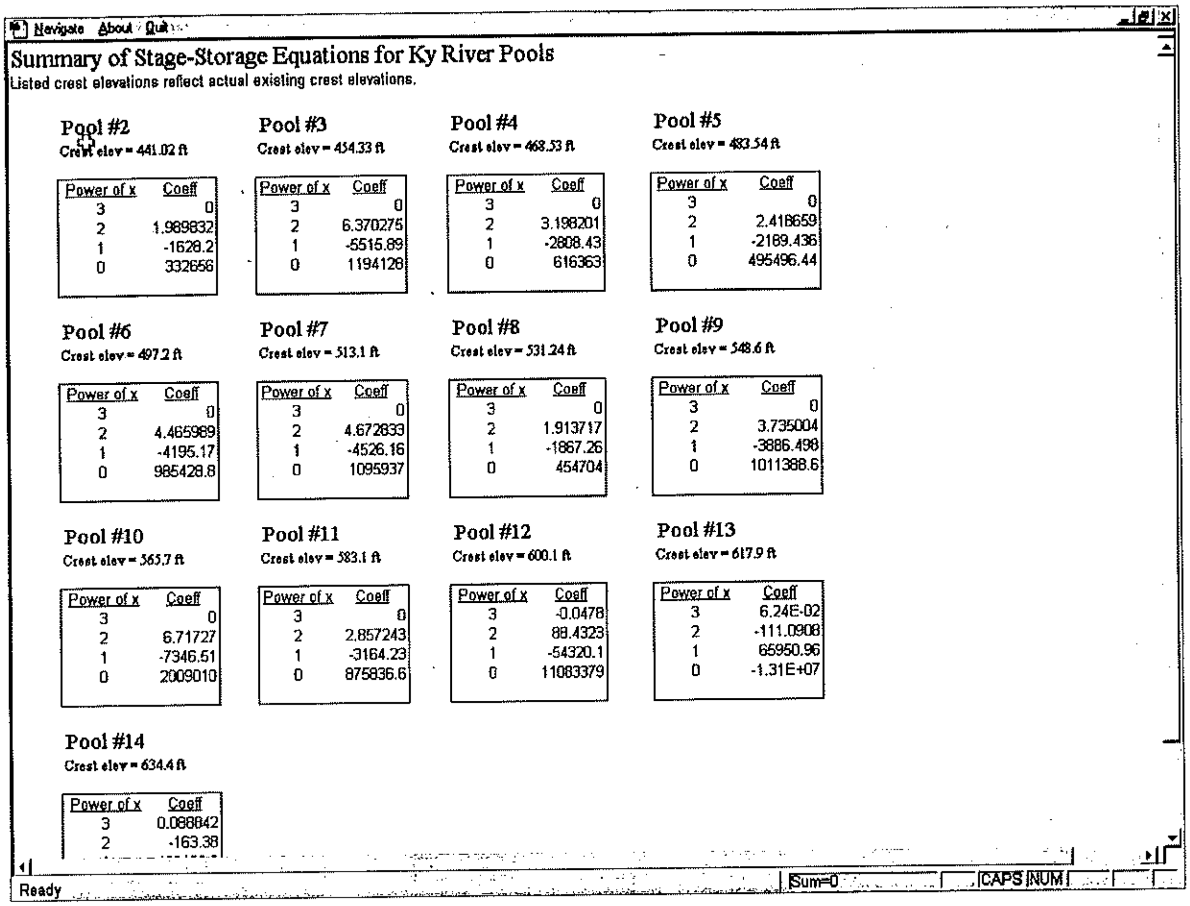
	Day 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Jan	757	757	757	757	757	757	757	757	757	757	757	757	757	757	757	757	757	757
Feb	757	757	757	757	757	757	757	757	757	757	757	757	757	757	757	757	757	757
Mar	757	757	757	757	757	757	757	757	757	757	757	757	757	757	757	757	757	757
Apr	757	757.8	758.67	760	760.3	761.2	762	762.8	763.67	764.5	765.3	766.2	767	767.8	768.7	769.5	770.3	771.2
May	782	782	782	782	782	782	782	782	782	782	782	782	782	782	782	782	782	782
Jun	782	782	782	782	782	782	782	782	782	782	782	782	782	782	782	782	782	782
Jul	782	782	782	782	782	782	782	782	782	782	782	782	782	782	782	782	782	782
Aug	782	782	782	782	782	782	782	782	782	782	782	782	782	782	782	782	782	782
Sep	782	781.7	781.45	781	780.9	780.6	780.4	780.1	779.8	779.5	779.3	779	778.7	778.4	778.2	777.9	777.6	777.3
Oct	773.758242	773.5	773.21	773	772.7	772.4	772.1	771.8	771.56	771.3	771	770.7	770.5	770.2	769.9	769.6	769.4	769.1
Nov	765.241758	765	764.69	764	764.1	763.9	763.6	763.3	763.04	762.8	762.5	762.2	761.9	761.7	761.4	761.1	760.8	760.6
Dec	757	757	757	757	757	757	757	757	757	757	757	757	757	757	757	757	757	757

Carr Fork

	Day 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Jan	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017
Feb	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017
Mar	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1018	1018
Apr	1020.82979	1021	1021.3	1021	1022	1022	1022	1022	1022.5	1023	1023	1023	1023	1024	1024	1024	1024	1024

Ready Sum=0 CAPS NUM

26. *Rule Curves Screen.* Reservoir release limits and rule curves are specified in the Rule Curves Screen. Values may be entered directly into the desired table. The Rule Curves Screen is accessed by selecting *Reservoir Rules* from the Navigate menu on the menubar.



Navigate About Quit

Summary of Stage-Storage Equations for Ky River Pools

Listed crest elevations reflect actual existing crest elevations.

Pool #2
Crest elev = 441.02 ft

Power of x	Coeff
3	0
2	1.989832
1	-1628.2
0	332656

Pool #3
Crest elev = 454.33 ft

Power of x	Coeff
3	0
2	6.370275
1	-5515.89
0	1194128

Pool #4
Crest elev = 468.53 ft

Power of x	Coeff
3	0
2	3.198201
1	-2808.43
0	616363

Pool #5
Crest elev = 483.54 ft

Power of x	Coeff
3	0
2	2.418659
1	-2189.436
0	495496.44

Pool #6
Crest elev = 497.2 ft

Power of x	Coeff
3	0
2	4.465989
1	-4195.17
0	985428.8

Pool #7
Crest elev = 513.1 ft

Power of x	Coeff
3	0
2	4.672833
1	-4526.16
0	1095937

Pool #8
Crest elev = 531.24 ft

Power of x	Coeff
3	0
2	1.913717
1	-1867.26
0	454704

Pool #9
Crest elev = 548.6 ft

Power of x	Coeff
3	0
2	3.735004
1	-3886.498
0	1011388.6

Pool #10
Crest elev = 565.7 ft

Power of x	Coeff
3	0
2	6.71727
1	-7346.51
0	2009010

Pool #11
Crest elev = 583.1 ft

Power of x	Coeff
3	0
2	2.857243
1	-3164.23
0	875836.6

Pool #12
Crest elev = 600.1 ft

Power of x	Coeff
3	-0.0478
2	88.4323
1	-54320.1
0	11083379

Pool #13
Crest elev = 617.9 ft

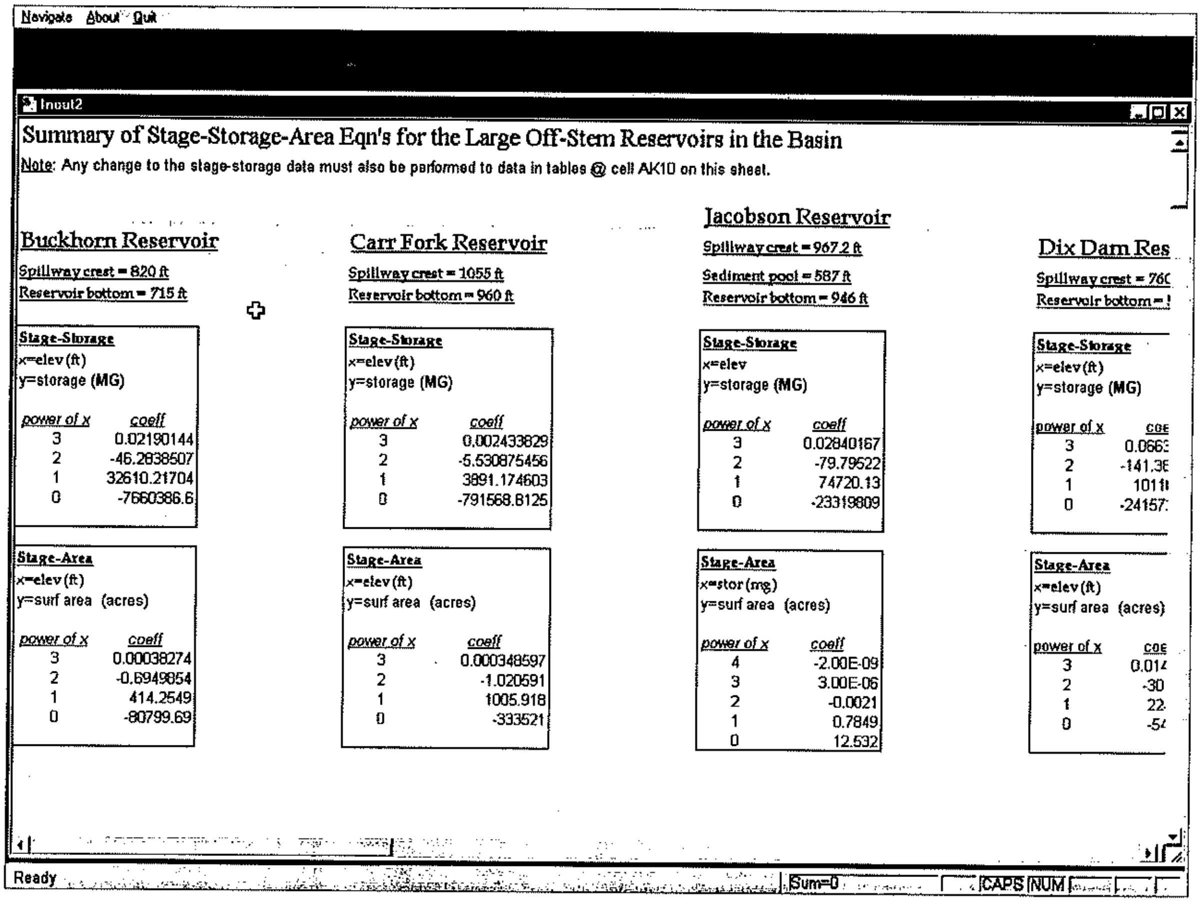
Power of x	Coeff
3	6.24E-02
2	-111.0908
1	65950.96
0	-1.31E+07

Pool #14
Crest elev = 634.4 ft

Power of x	Coeff
3	0.088842
2	-163.38

Ready Sum=0 CAPS NUM

27. *Pool Stage-Storage Screen.* The equations used to define the stage-storage characteristics of each of the mainstem pools are located on the Pool Stage-Storage Screen. Coefficients for the third order polynomial equations are identified in the tables for each mainstem pool. This screen is accessed by selecting *Stage-Storage (Pools)* from the Navigate menu on the menubar.



28. *Reservoir Stage-Storage-Area Screen.* The equations used to define the stage-storage and stage-area characteristics of each of the four major reservoirs are located on the Reservoir Stage-Storage-Area Screen. Coefficients for the third-order polynomial equations are identified in the tables for each reservoir. This screen is accessed by selecting *Stage-Storage-Area (Reservoirs)* from the Navigate menu on the menubar.

Navigate About Quit

Pan Evap Data for Calculation of Evap Losses for Reservoirs

The daily pan evap values listed below were obtained from a monthly temp-evap model (developed from a random sample of recorded values from 1978 - 1995).
Evap values are not listed for the non-summer months since evaporation losses are relatively insignificant during these times.

	Day											
Month	1	2	3	4	5	6	7	8	9	10	11	12
APR		0.11	0.01	0.14	0.12	0.13		0.09	0.07	0.22	0.19	
MAY	0.07	0.2	0.23	0.14		0.06	0.08	0.02	0.1	0.15	0.18	
JUN	0.35	0.18	0.25	0.21	0.29	0.24	0.07	0.15	0.23	0.25	0.11	
JUL	0.2	0.21	0.27	0.2	0.13	0.14	0.32	0.14	0.24	0.21	0.21	
AUG	0.22	0.18	0.17	0.18	0.22	0.12	0.12	0.2	0.23	0.1	0.15	
SEP	0.21	0.18	0.22	0.24	0.25	0.2	0.16	0.17	0.08	0.25	0.14	

DO NOT CHANGE DATA IN THIS TABLE DIRECTLY; INFORMATION IS WRITTEN HERE FOR EXPORT TO ENGINE FILES
MAKE CHANGES TO EVAP DATA IN THE APPROPRIATE TABLE BELOW.

NOTE:
1930 Daily pan evap values were obtained from a monthly temp-evap model (developed from a random sample of recorded values from 1978 - 1995).
1953 Daily pan evap values were obtained from historical measurements in 1953 from Burgin Dix Dam station.

1930 Pan Evap Database

1930	Day											
Month	1	2	3	4	5	6	7	8	9	10	11	12
APR	0.16	0.12	0.17	0.15	0.19	0.18	0.14	0.13	0.17	0.24	0.27	0.28
MAY	0.26	0.26	0.23	0.26	0.29	0.30	0.26	0.27	0.28	0.27	0.25	0.27
JUN	0.21	0.26	0.28	0.28	0.25	0.21	0.14	0.11	0.16	0.16	0.23	0.27
JUL	0.23	0.16	0.16	0.21	0.30	0.33	0.32	0.31	0.31	0.34	0.34	0.35
AUG	0.25	0.29	0.29	0.32	0.30	0.32	0.30	0.33	0.29	0.23	0.18	0.19
SEP	0.27	0.28	0.22	0.22	0.24	0.27	0.22	0.22	0.22	0.21	0.22	0.24

1953 Pan Evap Database

1953	Day

Ready | Sum=0 | CAPS NUM

29. *Evaporation Data Screen.* The pan evaporation values associated with each drought year are located on the Evaporation Data Screen. The upper table displays the data for the current drought year. The databases for each drought year are located in the lower tables. The pan evaporation data in the tables is applied to the major reservoirs only. The Evaporation Data Screen is accessed by selecting *Evap Data* from the Navigate menu on the menubar.

Navigate About Quit

Historical Streamflow Trace for 1930 Drought

All flows and laterals are in CFS.

Abbreviations:

NF=North Fork of Ky River	b/w=between	BH=Buckhorn Reservoir	Tall=Gage @ Tallega
SF=South Fork of Ky River	u/s=upstream	Haz=Gage @ Hazard	Boon=Gage @ Booneville
MF=Middle Fork of Ky River	CF=Carr Fork	Jack=Gage @ Jackson	

Date	x Buckhorn Dam Inflow	x MF Lats b/w BH & Tallega	x Carr Fork Dam Inflow	x CF Lats b/w CF Dam & mouth of CF river	x NF Flow just u/s CF river mouth	x NF Lats b/w CF river and Haz	x NF Lats b/w Haz & Jack	x Flow @ Booneville	x Lats to 14	x Lats to 13	x Lats to 12	x L:
1-Jan-30	485.7	191.8	90.2	35.6	552.1	7.8	934.3	1000	0.0	277.9	288.9	
2-Jan-30	398.7	157.4	74.0	29.2	453.2	6.4	767.1	825	596.7	219.1	227.7	
3-Jan-30	431.7	170.4	80.2	31.7	490.7	6.9	830.5	1000	367.8	409.7	425.9	
4-Jan-30	521.7	206.0	96.9	38.2	593.0	8.4	1003.5	1120	423.8	235.8	245.1	
5-Jan-30	485.7	191.8	90.2	35.6	552.1	7.8	934.3	1000	662.6	185.0	192.3	
6-Jan-30	413.7	163.3	76.8	30.3	470.3	6.6	795.9	892	509.5	193.1	200.7	
7-Jan-30	368.8	145.6	68.5	27.0	419.2	5.9	709.4	758	479.3	181.1	188.2	
8-Jan-30	323.8	127.8	60.1	23.7	368.0	5.2	622.9	688	422.7	288.9	300.2	
9-Jan-30	266.8	105.3	49.6	19.6	303.3	4.3	513.3	758	639.8	482.2	501.2	
10-Jan-30	239.8	94.7	44.5	17.6	272.6	3.9	461.4	758	512.3	390.2	405.5	
11-Jan-30	226.4	89.4	42.0	16.6	257.3	3.6	435.4	645	246.1	279.5	290.5	
12-Jan-30	212.9	84.0	39.5	15.6	242.0	3.4	409.5	555	32.6	216.2	224.7	
13-Jan-30	188.9	74.6	35.1	13.8	214.7	3.0	363.4	515	231.5	216.3	224.8	
14-Jan-30	200.9	79.3	37.3	14.7	228.3	3.2	386.4	578	111.8	313.9	326.3	
15-Jan-30	188.9	74.6	35.1	13.8	214.7	3.0	363.4	690	259.1	369.2	383.7	
16-Jan-30	188.9	74.6	35.1	13.8	214.7	3.0	363.4	735	-11.0	314.3	326.6	
17-Jan-30	176.9	69.8	32.8	13.0	201.1	2.8	340.3	622	-10.9	232.5	241.6	
18-Jan-30	176.9	69.8	32.8	13.0	201.1	2.8	340.3	535	7.5	176.3	183.3	
19-Jan-30	149.3	58.9	27.7	10.9	169.7	2.4	287.2	440	-87.2	145.4	151.2	
20-Jan-30	122.9	48.5	22.8	9.0	139.7	2.0	236.5	357	-206.9	134.0	139.3	
21-Jan-30	138.5	54.7	25.7	10.2	157.4	2.2	266.5	360	38.0	109.8	114.2	
22-Jan-30	159.5	63.0	29.6	11.7	181.3	2.6	306.8	440	-134.5	139.4	144.9	
23-Jan-30	176.9	69.8	32.8	13.0	201.1	2.8	340.3	475	-281.7	120.0	124.7	
24-Jan-30	200.9	79.3	37.3	14.7	228.3	3.2	386.4	515	-525.1	107.5	111.7	
25-Jan-30	212.9	84.0	39.5	15.6	242.0	3.4	409.5	578	-204.5	79.2	82.4	
26-Jan-30	239.8	94.7	44.5	17.6	272.6	3.9	461.4	578	-573.7	88.4	91.8	
27-Jan-30	293.8	116.0	54.6	21.5	334.0	4.7	565.2	688	-352.8	118.2	122.8	
28-Jan-30	431.7	170.4	80.2	31.7	490.7	6.9	830.5	1550	1234.8	445.8	463.3	
29-Jan-30	596.6	235.5	110.8	43.7	678.2	9.6	1147.7	1850	1158.0	481.3	500.2	
30-Jan-30	368.8	145.6	68.5	27.0	419.2	5.9	709.4	1550	1136.5	428.9	445.8	

Ready Sum=110.7 NUM

30. *Streamflow Trace Screen.* There are two Streamflow Trace Screens in the model. They display the historical inflow data for each river reach for the two design droughts (e.g. 1930 & 1953). The appropriate Streamflow Trace Screen is loaded during simulation, based on the drought selected in the Drought Year Box (#11). The Streamflow Trace Screens may be accessed by selecting them from the Navigate menu in the menubar.

How Do I … ?

The following sections are designed as a quick-reference tutorial for the user. It is recommended the user review each section as he/she inputs data to ensure proper understanding of each parameter. Each section is devoted to a solitary task identified in the title. The following is a list of the sections.

How Do I … Specify the design drought?
How Do I … Specify municipal demands?
How Do I … Specify irrigation demands?
How Do I … Set minimum flow requirements at river locations?
How Do I … Set initial water levels?
How Do I … Set dam crest elevations?
How Do I … Set critical intake elevations?
How Do I … Specify reservoir or lock and dam leakages?
How Do I … Modify reservoir rule curves?
How Do I … Specify reservoir release limits?
How Do I … Specify additional reservoir releases?
How Do I … Change return flow percentages?
How Do I … Add an additional demand withdrawal on the river?
How Do I … Change pool stage-storage data?
How Do I … Change the stage-storage-area data of the major reservoirs?
How Do I … Specify Jacobson Reservoir characteristics?
How Do I … Install low-level valves at lock and dam locations?
How Do I … Specify pool transfers with low-level valves?
How Do I … Install crest gates on mainstem dams?

Each section provides a step-by-step procedure to perform the task identified in its title. Included is a detailed definition of the input parameter and a brief explanation of its usage by the model. This is provided to ensure proper characterization of the river system by the user.

How Do I … Specify the design drought?

Parameter Definition: The design drought refers to the historical drought conditions that will be imposed on the basin during simulation. The model supports two historical droughts: the 1930 drought of record and the 1953 drought.

Model Usage: The model has a database of estimated historical inflows into each river reach for both the 1930 and 1953 droughts. The model responds to the user's selection by loading the appropriate inflow trace during simulation. Pan evaporation data, which is used to compute evaporation losses from the major reservoirs, is also selected based on the drought year selection.

Data Source: Historical drought inflows for each river reach were determined by simulating the river basin under 1930 and 1953 conditions. A hydraulic river routing model, coupled with historical USGS streamflow data and a linear optimizer, was used to solve for the reach inflows. A complete discussion of the methodology used to construct reach inflows is contained in the report *Task III Deficit Analysis* (KWRRI, 1996).

Procedure:

❶ Move the mouse over the basin map and click the right mouse button to bring up the *Main Menu.*

❷ From the Main Menu select *Design Drought.*

❸ In the pop-up window that appears, select the desired design drought by right-clicking the circle to the left of the drought year. The blackened circle denotes the current selection.

❹ Press the OK button to confirm your selection and dismiss the pop-up window.

Remarks: When the pop-up window appears, the current design drought is identified by a blackened circle. Pressing the CANCEL button on the pop-up window will dismiss the window without accepting any changes.

How Do I … Specify municipal demands?

Parameter Definition: Municipal demands are those withdrawals from the mainstem of the Ky. River and its tributaries used to satisfy residential, commercial, and industrial demands.

Model Usage: Municipal demands are withdrawn from the river after natural losses, irrigation demands, and minimum flow requirements (if applicable) have been withdrawn. If the remaining water supply is insufficient to satisfy the daily municipal demand for a pool, then a deficit is experienced equal to the unsatisfied demand. Water supply remaining after losses and available for municipal withdrawal is determined by the critical storage for the pool. Critical storage is the storage in a pool corresponding to the lowest level in the pool for which municipal demand withdrawal is still permitted. Water below the critical storage level is not available for municipal withdrawal. The critical storage level is dependent upon minimum flow requirements, pool stage-discharge relationships, low-level valve locations, and critical intake elevations.

Data Source: Municipal withdrawal locations were obtained from the Kentucky Division of Water surface water withdrawal permits. Municipal demand forecasts were estimated by the UK/WRRI Economics group. A complete discussion of the methodology used to quantify municipal demand forecasts appears in the report *Water Use Estimation and Forecasting for the Kentucky River Basin* (Blomquist, et al, 1996).

Procedure:

❶ Move the mouse over the basin map and click the right mouse button to bring up the *Main Menu.*

❷ From the Main Menu select *Demand Forecast.*

❸ A pop-up window will appear prompting the user to either choose from a predefined list of municipal demand forecasts or go to the UK/WRRI Drought Forecast Model (DFM). Select your choice by right-clicking the mouse on it. The circle will appear blackened for the current selection. The predefined list includes a complete set of demand forecasts for the basin under 1930 weather conditions and a constant per capita water use. The DFM allows the user to generate his/her own demand forecast by selecting from a list of input parameters. Forecasts created in the DFM can be directly imported into KYBASIN. See the **Virtual Tour** section for a description of the DFM.

❹ Press the OK button to confirm your selection and dismiss the pop-up window.

❺ If you elected to select from the predefined forecasts, then a subsequent pop-up window appears. Select the desired demand forecast year by right-clicking the mouse on it. Press the OK button to confirm your selection. Pressing the CANCEL button will dismiss the pop-up window without changing the original demand forecast.

❻ If the user selected the DFM option, then the DFM will open automatically. When the user has completed generating a demand forecast, he/she can load the demand forecast into the KYBASIN model by pressing the appropriate button (see **Virtual Tour**). If the user elects not to load the forecast generated in the DFM, then the original demand forecast in the KYBASIN model will remain unchanged.

Remarks: The above steps indicate how to load demand forecasts for all municipal withdrawals. You can change individual demands by changing them in the demand template manually. The demand template can be accessed from the Navigate menu on the menubar.

How Do I … Specify irrigation demands?

Parameter Definition: Irrigation demands are those withdrawals from the mainstem of the Ky. River and its tributaries used for watering crops and livestock.

Model Usage: Irrigation demands are subtracted from a river reach prior to municipal demands, but subsequent to natural losses (e.g. evaporation, groundwater recharge, etc.). It is assumed irrigation withdrawals may be taken at any depth in the river.

Data Source: Default irrigation demands appear in the original model file. KYBASIN's default database of irrigation demands was estimated by the UK/WRRI Economics Group using current agricultural census data. No estimation was made for irrigation demands in future years. A complete discussion of the methodology used to quantify irrigation demand forecasts appears in the report *Water Use Estimation and Forecasting for the Kentucky River Basin* (Blomquist, et al, 1996).

Procedure:

❶ Select *Irrigation Demands* from the *Navigate* menu on the menubar at the top of the screen.

❷ In the Irrigation Demands Screen, enter the desired demand for each river reach. Note that irrigation demands are given monthly and represent the average daily demand, in million gallons per day (mgd), for every day in the month.

❸ Click on *Main* in the *Navigate* menu on the menubar to return to the Opening Screen.

Remarks: Unsatisfied irrigation demands are not included in deficit calculations. Irrigation demands do influence water available for withdrawal by municipal demands.

How Do I … Set minimum flow requirements at river locations?

Parameter Definition: Minimum flow requirements are DOW-enforced minimum flowrates in the river that have been deemed necessary in order to preserve water quality. The DOW, through use of its withdrawal permits, currently enforces minimum flow requirements at select river locations. Minimum flows in the river are mandated to protect river ecosystems by providing adequate dilution to incoming pollution from waste water treatment discharges and agricultural runoff.

Current DOW policy states that the minimum flowrate specified at each river location must be allowed to pass downstream. Consequently, if inflow into a mainstem pool is less than the minimum flow requirement at the pool, then the entire inflow must be allowed to pass downstream (i.e. municipal withdrawals must cease).

Model Usage: Minimum flow requirements are treated as a demand on water supplies that is senior to municipal demands but junior to irrigation demands and natural losses. If minimum flow requirements cannot be met, then a deficit in the river pool is encountered equal to the municipal demand. In a valved river system, minimum flow requirement *policy* is met with the valves, but pool storage below crest is not used to augment deficient pool inflows to minimum flow requirement levels.

Data Source: Default values for the minimum flow requirements are present in the original model file. Minimum flow requirements for river locations were obtained from the DOW.

Procedure:

❶ Move the mouse over the basin map and click the right mouse button to bring up the *Main Menu.*

❷ From the Main Menu select *Min Flow Requirement.*

❸ At the pop-up window that appears, select whether you wish to have minimum flow requirements enforced by clicking on the desired choice. The darkened circle denotes the current selection.

❹ If the user elects to enforce minimum flow requirements an input screen will appear. To modify the default values, move to the desired location and enter the new minimum flow requirement, in cubic feet per second (cfs), for that location. Clicking on *Main* in the *Navigate* menu on the menubar will return you to the Opening Screen.

❺ If the user elected not to enforce minimum flow requirements, then the model is instructed to ignore the values in the input table and the user is returned to the opening screen.

Remarks: It should be noted that while the DOW may relax minimum flow requirements in the event a state water emergency is declared, the model is not designed to make that assessment and minimum flow requirements will remain enforced during a drought.

How Do I … Set initial water levels?

Parameter Definition: Initial water levels are the water levels in main stem pools at the beginning of the 12-month simulation period. An initial water level for each main stem pool must be specified. All elevations in the model use the National Geodetic Vertical Datum of 1929.

Model Usage: The model uses the initial water levels as a starting point for the hydraulic calculations.

Data Source: No default values for initial water levels are provided. This is a user-required input.

Procedure:

❶ Move the mouse over the basin map and click the right mouse button to bring up the *Main Menu.*

❷ From the Main Menu select *Initial Water Levels*.

❸ In the table that appears, enter the desired initial water level, in feet, for each main stem pool and major reservoir.

❹ Click on *Main* in the *Navigate* menu on the menubar to return to the Opening Screen.

Remarks: If you are unsure of an appropriate value for initial water levels in the main stem pools, use a value of 1' above the dam crest elevation. Initial water levels usually will have little or no impact on predicted deficits, since most deficits occur during the summer months. For major reservoirs you may use the rule curve elevation for the initial water level, if you are uncertain.

How Do I … Set dam crest elevations?

Parameter Definition: The dam crest elevation is the elevation of the top of the dam structure on main stem dams. The dam crest elevation should not include the increase in elevation resulting from a crest gate. Crest gate elevation increases are considered separately. Dam crest elevations must be specified for each main stem lock and dam location. All elevations in the model use the National Geodetic Vertical Datum of 1929.

Model Usage: The model uses the dam crest elevations to establish discharges over dam crests during the simulation.

Data Source: Default values for dam crest elevations were obtained from the Army Corps of Engineers.

Procedure:

❶ Move the mouse over the basin map and click the right mouse button to bring up the *Main Menu*.

❷ From the Main Menu select *Dam Crest Elevations*.

❸ In the table that appears, enter the desired dam crest elevations, in feet, for each main stem lock and dam.

❹ Click on *Main* in the *Navigate* menu on the menubar to return to the Opening Screen.

Remarks: Permanent increases in dam crest elevations can be evaluated by changing default values. Permanent increases that are more than 5' over existing (default) elevations may result in erroneous output. The error is due to insufficient stage-storage data at the higher elevations. It is recommended that the user make a careful observation of model output to assess its validity when attempting to simulate increases in dam crest elevations in excess of 5'over default values.

How Do I … Specify reservoir or lock and dam leakages?

Parameter Definition: Reservoir / lock and dam leakage is the average daily flow that leaks through the dam structure of the impoundment. For reservoirs the leakage value is defined as a constant flowrate independent of the water level in the reservoir. For locks and dams it is defined as the leakage that occurs when the water level in the pool is equal to the dam crest elevation.

Model Usage: The model uses the inputted leakage values to assess reductions in pool / reservoir storages during the simulation. The inputted leakage values for mainstem locks and dams are used to derive stage-leakage equations for the lock and dam structures. These relationships are based on a standard orifice equation, which predicates an exponential decrease in leakage as pool levels decrease.

Data Source: The default leakage value for all the mainstem locks and dams is 50 cfs. This value is considered a "best guess" and was extracted from previous studies in the area by the Army Corps of Engineers and Harza Engineering Co.

Procedure:

❶ Move the mouse over the basin map and click the right mouse button to bring up the *Main Menu.*

❷ From the Main Menu select *Dam Leakages.*

❸ In the table that appears, enter the desired leakage values, in cubic feet per second (cfs), for main stem lock and dams or major reservoirs.

❹ Click on *Main* in the *Navigate* menu on the menubar to return to the Opening Screen.

Remarks: Lock and dam leakages are considered applicable towards satisfying minimum flow requirements.

How Do I ... Set critical intake elevations?

Parameter Definition: The critical intake elevation is defined in the model as the elevation in a pool below which withdrawal intakes can no longer function properly and municipal demand withdrawals must cease. Only one critical intake elevation is specified for each river reach, regardless of the number of intakes located in the reach. A critical intake elevation must be specified for each main stem pool prior to performing a simulation. All elevations in the model use the National Geodetic Vertical Datum of 1929.

Model Usage: The model uses the critical intake elevation in a pool to help establish whether municipal withdrawals are possible. When the water levels dip below the critical intake elevation a deficit is encountered equal to the total unsatisfied demand in the reach.

Data Source: The default values for critical intake elevations were obtained from the Authority and contact with individual municipal withdrawers. Default elevations reflect the invert elevations of intake pipes.

Procedure:

❶ Move the mouse over the basin map and click the right mouse button to bring up the *Main Menu.*

❷ From the Main Menu select *Critical Intake Elevations.*

❸ In the table that appears, enter the critical intake elevation, in feet, for each river reach shown.

❹ Click on *Main* in the *Navigate* menu on the menubar to return to the Opening Screen.

Remarks: In many cases where minimum flow requirements are enforced, the critical intake elevation is irrelevant. This is true because municipal demands are prohibited when minimum flow requirements can no longer be met. For the default lock leakages and minimum flow requirements, this occurs at elevations slightly above the dam crest and presumably is considerably higher than the critical intake elevation.

How Do I ... Specify reservoir release limits?

Parameter Definition: Reservoir release limits refer to the maximum and minimum allowable releases from a reservoir. The maximum release limit may be equal to the spillway capacity or may be dictated by downstream flood potential. The minimum release requirement refers to the DOW-mandated release necessary to preserve downstream water quality.

Model Usage: The model uses reservoir release limits to ensure reservoir releases are operating within the realistic range.

Data Source: The default maximum release limits for the three major reservoirs were obtained from the Army Corps of Engineers (Buckhorn and Carr Fork) and Kentucky Utilities (Dix). Default minimum release requirements were obtained from the DOW.

Procedure:

❶ Select *Reservoir Rules* from the *Navigate* menu on the menubar at the top of the screen.

❷ In the Release Limits table located above the reservoir rule curve tables, enter the desired maximum and minimum release limits for the three major reservoirs in the basin.

❸ Click on *Main* in the *Navigate* menu on the menubar to return to the Opening Screen

Remarks: The minimum flow requirement specification for Buckhorn, Carr Fork, and Dix reservoirs is identical to the minimum release limit. These values should be consistent with one another.

How Do I ... Modify reservoir rule curves?

Parameter Definition: A reservoir rule curve is a schedule of daily desired, or target, elevations in the reservoir. A reservoir rule curve is usually determined based on a number of factors, including flood storage, water supply storage, hydropower potential, and recreation benefit. A rule curve must be specified for each of the three major reservoirs (Buckhorn, Carr Fork, and Dix) in the basin for a successful simulation. Rule curve elevations are given relative to the National Geodetic Vertical Datum of 1929.

Model Usage: The model uses a reservoir's rule curve to simulate reservoir operation. Reservoir releases are used to match reservoir levels to the rule curve. When reservoir levels are above daily rule curve targets, water is released to restore levels to rule curve levels, up to the maximum allowable release limit. When water levels are below daily rule curve targets, only the minimum release requirement, if applicable, is released.

Data Source: The default rule curves for the three major reservoirs were obtained from the Army Corps of Engineers (Buckhorn and Carr Fork) and Kentucky Utilities (Dix).

Procedure:

❶ Select *Reservoir Rules* from the *Navigate* menu on the menubar at the top of the screen.

❷ In the Rule Curves Screen, you can modify the daily rule curve targets for any of the three major reservoirs (Buckhorn, Carr Fork, and Dix) by entering a new target, in feet, in the tables shown.

❸ Click on *Main* in the *Navigate* menu on the menubar to return to the Opening Screen

Remarks: Reservoir releases can significantly affect river flows. Care should be taken to obtain realistic rule curve data. The reservoir rule curve is a desired daily water level target for the reservoir. Specifying a reservoir rule curve does not guarantee that reservoir levels will equal the desired target levels, since precipitation (or the lack of) greatly influences reservoir levels. It is therefore recommended the user examine the reservoir output from the model to determine actual reservoir behavior.

How Do I ... Specify additional reservoir releases?

Parameter Definition: The user may elect for a reservoir to release more water than is needed to maintain its rule curve. This is termed as an additional reservoir release in the model. An additional reservoir release is usually a pulse release used for low-flow augmentation. Additional reservoir releases are an optional parameter in the model and are not required in order to perform a successful simulation.

Model Usage: In the model, additional reservoir releases are made on top of the release made to maintain the daily rule curve target. Total reservoir releases are compared with the maximum allowable release limit for the reservoir. If a total release exceeds the maximum limit, then the actual release made from the reservoir is restricted to the maximum limit.

Data Source: No default values for additional reservoir releases are provided. This is an optional input parameter.

Procedure:

❶ Move the mouse over the basin map and click the right mouse button to bring up the *Main Menu.*

❷ From the Main Menu select *Addt'l Reservoir Releases*.

❸ In the table that appears, enter the desired additional release, in cubic feet per second (cfs), for the reservoirs. Releases are input monthly and reflect the average daily release from the reservoir for every day in the month.

❹ Click on *Main* in the *Navigate* menu on the menubar to return to the Opening Screen.

Remarks: The reservoir release requests entered in the table are not guaranteed to be released, since this may cause the maximum release limit to be exceeded. It is therefore recommended the user examine the reservoir output from the model to determine actual reservoir behavior.

It should be noted that additional release requests are ambivalent to the rule curve, and release requests will be made (if maximum release limit is not violated and there is sufficient water in the reservoir) regardless of the reservoir water level. The effect of additional release requests on reservoir levels can be seen by examining reservoir output from the model.

How Do I ... Change return flow percentages?

Parameter Definition: Return flow percentage is defined as the percentage of municipal withdrawals that returns to the river as waste water treatment plant (WWTP) discharges. Return flow rates are computed by comparing the demand withdrawal to the associated WWTP discharge rates. A return flow percentage of 0.60 indicates that 60% of water withdrawn from the river for municipal demand is returned to the river by the WWTP or, conversely, that there is a 40% consumptive loss in water withdrawn for municipal demands. In the model, a separate return flow percentage must be specified for each major WWTP on the river. A basin average is used for the smaller WWTP's.

Model Usage: Return flow rates are used in the model to assess river inflows from WWTP discharges. Each WWTP is associated with a municipal demand. WWTP discharges are computed by multiplying the associated municipal withdrawal times the return flow percentage.

Data Source: The default return flow rates for the major WWTP's were calculated by relating a select sample of 1986-1994 dry weather discharges to the corresponding withdrawals by the perceived primary municipal supplier. The basin average rate was developed by a weighted average of the rates developed for the major WWTP's in the basin. For more information consult the *Task III Deficit Analysis* report (KWRRI, 1996)

Procedure:

❶ Select *Return Flow %* from the *Navigate* menu on the menubar at the top of the screen.

❷ In the table that appears, enter the desired return flow percentages for the major WWTP's or edit the basin average rate.

❸ Click on *Main* in the *Navigate* menu on the menubar to return to the Opening Screen

Remarks: When modifying the default return flow rates be sure to note the dependent withdrawer. The dependent withdrawer is the municipal withdrawal to which the return flow rate will be multiplied to generate the WWTP discharge.

How Do I ... Add an additional demand withdrawal on the river?

Parameter Definition: An additional demand withdrawal on the river is defined as a new municipal withdrawal. The model is equipped to accommodate new demand withdrawals on main stem river pools only. (Although you could lump a new demand withdrawal with an existing demand withdrawal). New demand withdrawals are referred to as the ADD# demand, where # refers to the pool where the withdrawal intake is located.

Model Usage: KYBASIN treats the ADD# demand as another municipal withdrawal from the # pool and are subject to the same limitations (e.g. junior to minimum flow requirements, prohibited at elevations below the critical intake elevation for the pool, etc.).

Data Source: No default values for additional demand withdrawals on mainstem river pools are provided. This is an optional input parameter.

Procedure:

❶ Move the mouse over the basin map and click the right mouse button to bring up the *Main Menu*.

❷ From the Main Menu select *Add a Demand.*

❸ In the municipal demand template that appears, enter monthly withdrawals for the new demand in the ADD# row under the associated withdrawal pool. Monthly demands reflect the average daily demand withdrawal, in million gallons per day (mgd), for every day in the month.

❹ Click on *Main* in the *Navigate* menu on the menubar to return to the Opening Screen.

Remarks: No attempt is made by the model to increase local WWTP discharges to reflect the new demand withdrawal, since there is no guarantee that the new demand withdrawal would utilize an existing local WWTP. If it is likely return flows from the new demand will discharge into the withdrawal pool, then the magnitude of monthly demands for this withdrawal should be identified as the net withdrawal (i.e. equal to the consumptive loss only).

How Do I ... Change pool stage-storage data?

Parameter Definition: Pool stage-storage data refers to the equations developed for each pool which define the storage in each pool at any given elevation. As with all elevation input data in the model, elevations are given in relation to the National Geodetic Vertical Datum of 1929.

Model Usage: The model uses the stage-storage data extensively in the simulation calculations. One equation is used for each mainstem river pool which completely describes the storage potential of a river pool from its bottom to elevations well above the dam crest. Equations are in the form of third-order (or less) polynomials, where the independent variable is elevation (ft) and the dependent variable is pool storage in million gallons.

Data Source: The default stage-storage equations were developed by fitting a third-order (or less) curve to stage-storage data obtained from the Kentucky Geological Survey (KGS) and the Army Corps of Engineers. The stage-storage data was developed from USGS quadrangle maps with a 20' contour interval.

Procedure:

❶ Select *Stage-Storage (Pools)* from the *Navigate* menu on the menubar at the top of the screen.

❷ In the input screen that appears, enter the coefficients for the new stage-storage curves. Equations must be of the form described in **Model Usage.** If a second-order polynomial is used, set the coefficient for the third-order term to zero.

❸ Click on *Main* in the *Navigate* menu on the menubar to return to the Opening Screen

Remarks: The stage-storage equations have a profound impact on model results. Extreme care should be taken when making changes to this data.

How Do I … Change the stage-storage-area data of the major reservoirs?

Parameter Definition: Reservoir stage-storage and stage-area data define the storage and surface area in the reservoir at any given elevation. Elevations are given in feet and are based on the National Geodetic Vertical Datum of 1929. Reservoir storage and surface area are given in million gallons and acres, respectively.

Model Usage: The model uses the stage-storage data extensively in the simulating the major reservoirs. Reservoir stage-area data is used by the model to compute evaporation losses. Both equations are in the form of third-order polynomials, with elevation as the independent variable and storage/area as the dependent variable.

Data Source: Default stage-storage-area equations for the reservoirs were developed from data provided by the Army Corps of Engineers (Buckhorn and Carr Fork), Kentucky Utilities (Dix), and Kentucky-American Water Co. (Jacobson).

Procedure:

❶ Select *Stage-Storage-Area (Reservoirs)* from the *Navigate* menu on the menubar at the top of the screen.

❷ In the input screen that appears, enter the coefficients for the new stage-storage-area curves. Equations must be of the form described in **Model Usage.** If a second-order polynomial is used, set the coefficient for the third-order term to zero.

❸ Click on *Main* in the *Navigate* menu on the menubar to return to the Opening Screen

Remarks: Accurate stage-storage equations are paramount to properly simulating reservoir behavior and available water supply. Extreme care should be taken when making changes to this data.

When reservoir stage-storage equations are changed, be sure to change the tables to the right of the coefficient data. These tables are located off-screen and you will have to use the right arrow key to locate them.

How Do I ... Specify Jacobson Reservoir characteristics?

Parameter Definition: The sediment pool elevation and maximum withdrawal rate must be identified for Jacobson Reservoir prior to performing a simulation. The sediment pool elevation is the elevation corresponding to the lowest possible level at which water is usable for demand withdrawal. Water levels below the sediment elevation contain too large a sediment loading to be suitable for withdrawal. The maximum withdrawal, as the name implies, corresponds to the maximum flowrate that can be withdrawn from the reservoir. The maximum withdrawal rate is dependent upon the size of the intake structure.

Model Usage: The model uses the sediment pool and maximum withdrawal rate to quantify available water supply and ensure that the reservoir is operated within realistic bounds.

Data Source: The default sediment pool level and maximum withdrawal rate were obtained from Kentucky-American Water Co.

Procedure:

❶ Select *Reservoir Rules* from the *Navigate* menu on the menubar at the top of the screen.

❷ In the table entitled Jacobson Operation located above the reservoir rule curve tables, enter the desired sediment pool, in million gallons, and maximum withdrawal rate, in mgd.

❸ Click on *Main* in the *Navigate* menu on the menubar to return to the Opening Screen

Remarks: Jacobson withdrawals will be limited by the maximum withdrawal rate and by the amount of storage above the sediment pool level. Evaporative losses are still possible at elevations below the sediment pool.

An initial water level is also required for Jacobson Reservoir (see **How Do I … Set initial water levels?)**. There is no refilling algorithm for Jacobson Reservoir during the simulation.

How Do I ... Install low-level valves at lock and dam locations?

Parameter Definition: Low-level valves refer to gate valves that could be installed in lock and dam structures to permit controlled releases from a pool at water elevations below the dam crest. Such a valve has been installed in lock and dam #11 and is being considered by the Authority at other locations.

A valved system offers two distinct advantages over a non-valved system at reducing drought impacts. First, the valve can be used to maintain minimum flow requirement policy, permitting legal "mining" of river pools by municipal withdrawals. ("Mining" of a pool refers to the depletion of pool storage below the dam crest.) Recall, that if minimum flow requirements are enforced, municipal demands must cease when pool inflows are less than minimum flow requirements. A second advantage of the valved system is that valves permit the transfer excess capacity from upstream river pools to satisfy downstream deficits. This is referred to as a *pool transfer*.

Model Usage: The model permits the installation of low-level valves in lock and dams #9 through #14 only. Low-level valves are automatically used to satisfy the minimum flow requirement *policy*, if enforced. Valves are not used to deplete storage below dam crests to augment deficient pool inflows to minimum flow requirement levels. In a valved pool, storage below is crest is eligible for municipal demand withdrawal, but is also still subject to natural losses, irrigation demands, and dam leakage. The model also permits pool transfers with the low-level valves. Pool transfers are discussed in **How Do I ... Specify pool transfers with low-level valves?**

Data Source: No default settings for low-level valve locations or operation are provided. This is an optional input parameter.

Procedure:

❶ Move the mouse over the basin map and click the right mouse button to bring up the *Main Menu.*

❷ From the Main Menu select *Low Level Valves*.

❸ At the pop-up window that appears, select whether you wish to consider low-level valves in the simulation by clicking on the desired choice. The darkened circle denotes the current selection. Selecting the CANCEL button will maintain the original low-level valve assumption.

❹ If the user elected to consider low-level valves, an input screen will appear. To install a low-level valve at a dam location, locate the *LLV Installed?* column in the table. At the desired lock and dam, type "TRUE" to install a valve; the text "FALSE" should appear at unvalved locations. For each low-level valve, the elevation at which it will no longer function must be entered in the *LL Valve Invert Elev* column in the table. All elevations must be given in feet and in relation to the NGVD of 1929. Clicking on *Main* in the *Navigate* menu on the menubar will return you to the opening screen.

❺ If the user elected not to consider low-level valves, then the model will not consider valves in the simulation and the Opening Screen will reappear.

Remarks: The capacity of the low-level valve is not computed by the model. Model users should check this manually to ensure that specified valve releases are possible.

In the model, valves may be located at any depth on the lock and dam structure. The user should exercise his/her engineering judgment as to whether valve elevations are practical.

How Do I ... Specify pool transfers with low-level valves?

Parameter Definition: Low-level valves may be used to transfer excess capacity from upstream river pools to satisfy downstream deficits. This is referred to as a *pool transfer*. A pool transfer loses effectiveness when it encounters an unvalved pool, since water exiting from the unvalved pool is severely limited at elevations below dam crest.

Model Usage: The model considers pool transfers independent of other flows in the river. As a consequence, water designated for pool transfer through a valve is not applied towards minimum flow requirements at the lock. Similarly, pool transfer water is not considered in establishing the pool inflow that must be allowed to pass downstream for the case when pool inflows are less than required minimums. Inflow into unvalved pools is not excluded from minimum flow requirements and withdrawal, regardless if the inflow was provided through an upstream pool transfer.

When a pool transfer is designated, the valves are opened to the setting which will permit the designated flow to pass. Consequently, pool transfers are not reduced by losses or demand withdrawal, since these losses will be absorbed by the pools themselves. The pool transfer algorithm is processed before withdrawals and losses are assigned to the pool to ensure the transfer is given the highest priority.

Pool levels are checked prior to transfer requests to ensure the water is available for transfer and that valves are submerged. Partial transfers may result if there is an insufficient storage in the pool or if water levels in the intermediate pools are below the valve elevation.

Data Source: No default settings for pool transfer requests are provided. This is an optional input parameter.

Procedure:

❶ Move the mouse over the basin map and click the right mouse button to bring up the *Main Menu.*

❷ From the Main Menu select *Valve Release Strategy*.

❸ In the table that appears, enter desired monthly valve releases, in million gallons per day (mgd), at the mainstem lock and dam locations. Monthly releases represent the average daily valve release from the pool for every day in the month. Use the valve releases to set up the desired pool transfer strategy.

❹ Click on *Main* in the *Navigate* menu on the menubar to return to the Opening Screen.

Remarks: The capacity of the low-level valve is not computed by the model. Model users should check this manually to ensure that specified valve releases are possible.

An effect of pool transfers is that water levels are reduced in the contributing pools. The reduced levels result in smaller discharges over the dam or in leakage flows. This can cause significant depletion of the immediately downstream pool due to the differential discharge/leakage rates in the upstream and downstream dams.

Pool transfers are requests for water and may not be honored if valves are exposed or there is insufficient water available. Model output should be reviewed to determine the actual water transferred.

You should verify valved lock locations prior to specifying pool transfers to ensure feasibility. Pool transfer requests will be ignored in unvalved locks.

To transfer water between non-adjacent pools, make sure that all intermediate valves are open to the desired flow-thru capacity. This may cause depletion of the intermediate pool if upstream release requests were not received and storage is available in the intermediate pool.

How Do I ... Install crest gates on mainstem dams?

Parameter Definition: Crest gates refer to mechanical gates that could be installed on existing mainstem dam structures which, when raised, would increase the dam crest elevation by the height of the gate. Crest gates can be raised before drought periods to increase the amount of water available in a river pool. Crest gates are usually lowered during wet periods to prevent unnecessary flooding of riparian land. Crest gates lose utility in drought periods if flow in the river is insufficient to fill up the increased storage capacity. Therefore, crest gate operation (i.e. determining raising/lowering times) is critical to its performance.

Model Usage: The model permits the installation of crest gates on mainstem dams #9 thru #14 only. Crest gates are originally in the lowered position at the beginning of the 12-month analysis period. Crest gates may be raised and lowered only once. No leakage is considered through the crest gate itself.

Data Source: No default settings for crest gate locations, sizes, or operation are provided. Crest gates are an optional input parameter.

Procedure:

❶ Move the mouse over the basin map and click the right mouse button to bring up the *Main Menu.*

❷ From the Main Menu select *Crest Gates*.

❸ At the pop-up window that appears, select whether you wish to consider crest gates in the simulation by clicking on the desired choice. The darkened circle denotes the current selection. Selecting the CANCEL button will maintain the original crest gate assumption.

❹ If the user elected to consider crest gates, an input screen will appear. To install a crest gate at a dam location, locate the *Crest Gate Elevation* column in the table. At the desired lock and dam, enter the elevation (based on the NGVD of 1929) of the top of the crest gate when in the raised position. Next, enter the raised and lowered dates in the associated *Month* and *Day* columns.

Months should be entered in numeric format (e.g. January = 1, February = 2, etc.). A lowered date must be entered if raised date is entered. If you do not wish to install a crest gate at a lock and dam location, set its crest gate elevation to the dam crest elevation. Clicking on *Main* in the *Navigate* menu on the menubar will return you to the Opening Screen.

❺ If the user elected not to consider crest gates, then the model will not consider crest gates in the simulation and the Opening Screen will reappear.

Remarks: In the model, crest gate heights may be set to any size. The user should exercise his/her engineering judgment as to whether these sizes are structurally feasible. Crest gate heights in excess of 5' may result in erroneous output. The error is due to insufficient stage-storage data at the higher elevations. It is recommended that the user make a careful observation of model output to assess its validity when attempting to simulate crest gate heights in excess of 5'.

References

Blomquist, Glenn C. and William H. Hoyt, 1996, Water Use Estimation and Forecasting for the Kentucky River Basin.

Kentucky Water Resource Research Institute (KWRRI), 1996, Task III - Deficit Analysis.