WATER RESOURCES BULLETIN
VOL. 19, NO. 1 AMERICAN WATER RESOURCES ASSOCIATION FEBRUARY 1983

GUIDELINES FOR INTERACTIVE COMPUTER SOFTWARE IN WATER RESOURCES ENGINEERING[1]

T. V. Hromadka II, J. M. Clements, and G. L. Guymon[2]

ABSTRACT: *A case study in the development of interactive computer* software for water resources related engineering problems is presented. Guidelines for the preparation of a uniform set of interactive program requirements are discussed. Use of the developed guidelines will reduce computer usage expenditures by minimizing program learning time and data entry errors.
(KEY TERMS: computers; interaction; water resources; programming techniques.)

INTRODUCTION

The use of computers to aid in water resources related analysis, synthesis, and design has increased significantly during the last decade. A main motivation for computer use is that water resource related studies often require (1) an itera- calculation analog such as used in the calculation of hy- ılic section information, (2) solution of a convolution type integral such as used in unit hydrograph hydrology studies, or (3) the solution of a simultaneous system of equations such as employed in water distribution network analysis. Because each of these three general classifications of problems essentially involve a repetitive series of calculations, a computer code can be prepared which will offer to the engineer an extremely cost effective tool (for example, Spence and Larock, 1979).

Another motivation for the use of computers in water resources related studies is the development and widespread use of digital microcomputers. For many classes of problems, the microcomputer offers the speed and capability to the single user as does a minicomputer system. Consequently, programming techniques which were once limited to the minicomputer or the mainframe class of computers is now available at low cost by means of a microcomputer system.

Such programming techniques include "humanized" computer interaction and detailed, easy to read computer results which are explicit, fit the requirement of a reviewing agency, and yet are understandable to the first time review of the product. Some examples of specially prepared computer results are shown in Figures 1 and 2.

By making the program humanized, the learning curve is essentially minimized in that all program information is prompted and scanned for acceptability and can be rejected if data is not within program specified limits. In general, the user's manuals associated with a wide variety of batch programs are eliminated because the humanized program guides the user through every possible logic path, providing the user with various checks and controls in order to further reduce parameter selection errors and an unreasonable choice of design options. By using a program which provides an optimum product, the usual design review procedure is minimized which reduces total cost to both the design engineer and the design review team. Additionally, the computer product should be the actual fully prepared report to be submitted, containing the usual introductory pages, and the study results produced in the reviewing agency required computer printed forms or plotted graphs. The computer program then provides an actual engineering product, minimizing the need of secretarial and graphic effort for report preparation.

This paper provides a case study in the preparation of humanized computer software for water resources engineering studies. Also, considerations are included of what should be in a computer software library development plan. A brief presentation of humanized software guidelines will be given along with examples. Use of the programming techniques for computer aided design will significantly enhance user capability with sophisticated computer software such as occurs in water resources engineering.

DISCUSSION

The authors prepared a library of water resources computer programs for hydraulic analysis of natural and urban watershed storm drain systems, and for the hydrologic determination of watershed runoff flow rates and runoff hydrographs. These computer programs are based on the several county flood control hydrology manuals which are used for design and analysis purposes in Southern California. Specifically, the counties

[1] Paper No. 82099 of the *Water Resources Bulletin*. Discussions are open until October 1, 1983.
[2] Respectively, General Partners, Advanced Engineering Software, 17792 Sky Park Blvd., Irvine, California 92671; and Professor, Civil Engineering, University of California, Irvine, California 92717.

*** (AES): IRREGULAR CHANNEL SUBCRITICAL FLOW MODEL ***
Standard Step Method irregular channel analysis. Based on development in "OPEN CHANNEL HYDRAULICS",CHOW(1959)
STUDY NAME: Channel Flow = 1000.00 cfs PAGE NUMBER:

LENGTH from CONTROL	WATER SURFACE (elev.)	FLOW DEPTH (ft)	FLOW AREA (ft*ft)	FLOW V (fps)	$aV^2/2g$ (ft)	TOTAL HEAD (ft)	HYDR RADIUS (ft)	FRICTION SLOPE Sf	AVERAGE REACH Sf	REACH LENGTH (ft)	LOSS Hf (ft)	EDDY LOSS (ft)	TOTAL HEAD (ft)	Fr
.0	105.91	5.91	99.4	10.06	1.729 a=1.10	107.639	3.16	.008885 n= .0300					107.639	1.00 GIVEN
100.0	107.21	6.71	123.5	8.10	1.121 a=1.10	108.335	3.47	.005061 n= .0300	.006973	100.0	.697	.00 e= .00	108.336	.77
200.0	107.73	6.73	123.6	8.09	1.119 a=1.10	108.845	3.42	.005155 n= .0300	.005108	100.0	.511	.00 e= .00	108.846	.78
300.0	108.26	6.76	124.4	8.04	1.105 a=1.10	109.362	3.38	.005177 n= .0300	.005166	100.0	.517	.00 e= .00	109.362	.78
400.0	108.79	6.79	125.4	7.97	1.087 a=1.10	109.880	3.34	.005171 n= .0300	.005174	100.0	.517	.00 e= .00	109.879	.78
500.0	109.33 SECTION	6.83	126.5	7.91	1.068 a=1.10	110.398	3.30	.005158 n= .0300	.005164	100.0	.516	.00 e= .00	110.397	.78
600.0	114.63	6.06	105.4	9.49	1.538 a=1.10	116.170	2.89	.008861 n= .0300	.007009	100.0	.701	.00 e= .00	111.099	*1.00 STEEP
700.0	120.62	5.98	107.4	9.31	1.482 a=1.10	122.106	2.81	.008875 n= .0300	.008868	100.0	.887	.00 e= .00	117.057	*1.00 STEEP
800.0	126.62	5.91	109.3	9.15	1.431 a=1.10	128.054	2.73	.008892 n= .0300	.008884	100.0	.888	.00 e= .00	122.994	*1.00 STEEP
850.0	129.63 SECTION	5.88	110.3	9.06	1.404 a=1.10	131.032	2.70	.008866 n= .0300	.008879	50.0	.444	.00 e= .00	128.498	*1.00 STEEP
900.0	130.24	6.24	119.3	8.38	1.200 a=1.10	131.438	2.76	.007355 n= .0300	.008110	50.0	.406	.00 e= .00	131.437	.91
1000.0	130.98 SECTION	6.48	118.4	8.45	1.220 a=1.10	132.202	2.65	.007902 n= .0300	.007628	100.0	.763	.00 e= .00	132.201	.93

Figure 1. Example Backwater Calculation Results for an Irregular Channel.

of Orange, Riverside, San Bernardino, and San Diego (Orange County Environmental Management Agency, 1978; Riverside County Flood Control and Water Conservation District, 1978; San Bernardino Flood Control, 1972; San Diego County Dept. of Public Works and Flood Control, 1975) are all large neighboring counties where watersheds cross jurisdictional boundaries and yet each county has specific and individualized methodologies for the hydrologic analysis of a watershed. The differences between hydrology manuals occur in parameter values, e.g., rational method and unit hydrograph soil loss functions, as well as methodology; e.g., the Soil Conservation Service hydrograph method in comparison to the U.S. Army Corps of Engineers unit hydrograph method. Several other differences between the hydrology manuals occur which oftentimes can affect the computed results, making them unacceptable on an intercounty basis.

Consequently, in the preparation of the hydrology and hydraulic computer programs for Southern California a significant effort was spent towards planning an interactive computer system which essentially unifies the several county methodologies for the program user. Such a program library would considerably help the engineer in overcoming oftentimes subtle differences in methodology which could become costly in the final analysis.

Therefore, the first step in any computer software preparation is the definition of the total problem to be solved. Upon description of the total problem the several equations, parameter functions, data and ancillary computational analogs can be combined into a logic flow chart which describes the design processes of the engineer. Included in this flow chart is the interaction of the engineer with the program so that the program user can select design alternatives or program options which control the flow chart decision paths.

For example, the hydrology rational method procedure used in the subject counties is to subdivide a watershed water course into several small subareas of about 10 to 50 acres each with the size increasing in the downstream direction along the water course. The usual rational equation is applied to each subarea where the time of concentration is assumed to be the sum of all upstream subarea travel times. Thus, the total runoff at some point is the sum of each upstream subarea incremental runoff value as determined by its respective time of concentration. Using this simple approach, runoff values are estimated along the water course in a downstream direction. Based on some point runoff, the engineer decides how to accommodate the flood flows to the next downstream point by designing storm sewers or other mitigative measures. Since the next downstream point of concentration develops a total runoff depending on the previous upstream point of concentration and the travel time for the routed storm waters to flow between these two points, the study proceeds only after the engineer interacts with the methodology. Even though the

```
|----------------------------------------------------------------------------------------------------------|
| STUDY NAME:                                                        | CALCULATED BY:                      |
|                                                                    |    CHECKED BY:                      |
| 25.0 YEAR STORM 1-HOUR RAINFALL(inch)= 1.49;INTENSITY SLOPE = .600 | PAGE NUMBER    OF                   |
|-------------------[A D V A N C E D   E N G I N E E R I N G   S O F T W A R E]---------------------------|
|CONCENTRATION|SOIL|DEV.|  AREA  | I  | C  |  Q  |   Q  |SLOPE|SECTION| V  |PATH| T  | Tc  |  HYDRAULICS   |
| POINT NUMBER|TYPE|TYPE|(ACRES) |in/h|    |(SUB)| TOTAL|ft/ft|       |fps.| ft.|min.| min.|   AND NOTES   |
|-------------|----|----|--------|----|----|-----|------|-----|-------|----|----|----|-----|---------------|
|-------------|----|----|--------|----|----|-----|------|-----|-------|----|----|----|-----|---------------|
|-------------|----|----|--------|----|----|-----|      |.0025|       |    | 800|20.3|-----|INITIAL SUBAREA|
|        12.00|  1 |  6 |    10.0|2.86|.631| 18.0|------|-----|-------|----|----|----| 20.3|---------------|
|-------------|----|----|--------|----|----|-----|  18.0|.0057| street| 3.1| 350| 2.1|-----|*Qavg=  26.7cfs|
| 44.ft STREET|    |    |        |    |    |     |      |     |       |    |    |    |     |Dn= .59 W= 21.7|
| flow to PT.#|    |    |        |    |    |     |      |     |       |    |    |    |     | X-fall= .02000|
|        13.00|  1 |  5 |     9.6|2.69|.669| 17.3|------|-----|-------|----|----|----| 22.4|---------------|
|-------------|----|----|--------|----|----|-----|  35.3|.0031|D= 39."| 5.8| 650| 1.9|-----|n=.0130 Dn= 2.2|
|        14.00|  1 |  5 |     6.0|2.57|.664| 10.2|------|-----|-------|----|----|----| 24.3|---------------|
|-------------|----|----|--------|----|----|-----|------|-----|-------|----|----|----|-----|---------------|
|        14.00|    |    |    25.6|2.57|    |     |  45.6|     |       |    |    |    | 24.3| Stream Summary|
|-------------|----|----|--------|----|----|-----|------|-----|-------|----|----|----|-----|---------------|
|-------------|----|----|--------|----|----|-----|      |.0075|       |    | 400|13.7|-----|INITIAL SUBAREA|
|        22.00|  1 |  7 |     1.0|3.61|.584|  2.1|------|-----|-------|----|----|----| 13.7|---------------|
|-------------|----|----|--------|----|----|-----|   2.1|.0024|B=   .5| 1.4| 850| 9.8|-----|n=.0300 Dn= 1.0|
|             |    |    |        |    |    |     |      |     |       |    |    |    |     |Z= 1.0 Fr=  .33|
|        14.00|  1 |  9 |     3.2|2.61|.432|  3.6|------|-----|-------|----|----|----| 23.5|---------------|
|-------------|----|----|--------|----|----|-----|------|-----|-------|----|----|----|-----|---------------|
|        14.00|    |    |     4.2|2.61|    |     |   5.7|     |       |    |    |    | 23.5| Stream Summary|
|-------------|----|----|--------|----|----|-----|------|-----|-------|----|----|----|-----|---------------|
|-------------|----|----|--------|----|----|-----|      |.0027|       |    | 750|43.3|-----|INITIAL SUBAREA|
|        32.00|  1 | 11 |     9.5|1.81|.351|  6.0|------|-----|-------|----|----|----| 43.3|---------------|
|-------------|----|----|--------|----|----|-----|   6.0|.0036| street| 1.9| 550| 5.3|-----|*Qavg=   9.0cfs|
| 44.ft STREET|    |    |        |    |    |     |      |     |       |    |    |    |     |Dn= .47 W= 15.4|
| flow to PT.#|    |    |        |    |    |     |      |     |       |    |    |    |     | X-fall= .02000|
|        33.00|  1 |  8 |     8.8|1.69|.393|  5.9|------|-----|-------|----|----|----| 48.6|---------------|
|-------------|----|----|--------|----|----|-----|  11.9|.0014|D= 30."| 3.3| 700| 3.5|-----|n=.0130 Dn= 1.7|
|        14.00|  1 |  3 |     4.8|1.62|.757|  5.9|------|-----|-------|----|----|----| 52.1|---------------|
|-------------|----|----|--------|----|----|-----|------|-----|-------|----|----|----|-----|---------------|
| CONFLUENCE  | TC#1= 24.3  TC#2= 23.5  TC#3= 52.1  TC#4=    .0  TC#5=    .0|    |    |     |    LARGEST    |
|  ANALYSIS   | Q#1=  45.6  Q#2=   5.7  Q#3=  17.8  Q#4=    .0  Q#5=    .0|    |    |     |   CONFLUENCE  |
| FOR POINT#  | I#1=  2.57  I#2=  2.61  I#3=  1.62  I#4=   .00  I#5=   .00|    |    |     |   Q=  59.5    |
|        14.00| Q1 =  59.5  Q2 =  57.9  Q3 =  50.2  Q4 =    .0  Q5 =    .0|----|----|-----|---------------|
|-------------|----|----|--------|----|----|-----|------|-----|-------|----|    |    |     |               |
|-------------|----|----|--------|----|----|-----|  59.5|.0036|D= 45."| 7.0| 550| 1.3|-----|n=.0130 Dn= 2.7|
|----------------------------------------------------------------------------------------------------------|
*DEVELOPMENT TYPES:1=COM,2=APT,3=MH,4=CONDO,5=SF(1/4-AC),6=SF(1/2-AC)          SOIL TYPES:1=A,2=B,3=C,4=D,*
*7=SF(1-AC),8=SF(2.5-AC),9=UNDEV(POOR COV),10=UNDEV(FAIR COV),11=UNDEV(GOOD COV) 0,5=SPECIFIED COEFFICIENT*
```

Figure 2. Example Rational Method Hydrology Study Results in Required Form.

computer program may size the necessary conduits between points, the engineer must interact with the program by accepting or rejecting the most recent computed results before proceeding with the downstream study. Consequently, the computer provides all the algorithmic computations, parameter selections, and flood flow information. Based on this intermediate data, the program user options are whether to accept the design and proceed to the next downstream point or to reject the design. If a design is rejected, an alternative design may be selected by the user and reviewed. Because the results are near instantly produced, the engineer and computer software interact to produce an optimum design product. This type of interactive design software closely follows the logic used in the normal design procedure should the engineer perform the study by hand and is, therefore, easy to adopt.

Once the interaction logic is developed for the global problem, the next step in the development of humanized software is to define a uniform Communication/Presentation (C/P) for the computer terminal (CRT). This step is the most important to the interactive program software, and oftentimes may far exceed the total software development cost expenditure compared to a primitive batch computer program. The following the minimum C/P requirements for the CRT:

1) The C/P should present all information in a readable manner so that the engineer can readily evaluate the computed data.

2) All units should be given for the data.

3) Any flow chart logic interaction should be clearly displayed so that the first time user can operate the software system.

4) Any program operation commands should be consistently and uniformly displayed so that the user can operate the interaction or special data editing features without confusion.

5) The C/P should be uniform between programs. By requiring uniformity of software interaction, individual programmer personality traits can be avoided. The result is a library of software wherein each program operates, interacts, and responds identically. Consequently, the user learning curve is minimized.

6) All computer dependent requirements (e.g., such as computer file manipulation) for data management should be interior of the software so that the program user need not be knowledgeable in the computer operations in order to perform computer aided design.

In the following section, a brief discussion of C/P interaction is presented and specific C/P terms defined. In a subsequent section, a useable humanized C/P procedure is diagrammed and discussed. The proposed C/P methods are programmable on most mainframe, minicomputers, and microcomputers which support a higher level program language (such as Fortran IV) and includes a CRT for the program user in the total computer system.

CONCEPTS OF COMPUTER/HUMAN COMMUNICATIONS

In the past, the typical manner of communication with a computer was by means of punched computer cards. The cards were returned to the user along with a printed output which sometimes only indicated the status of how well the data deck was assembled. This process was repeated until the desired result was obtained. This type of interaction with a computer is extremely inefficient and promotes only one direction of communication between the computer and user.

A marked improvement in computer/human communications was the utilization of the cathode ray terminal (CRT) for the data entry via the keyboard and program access. This gave the user a "hands on" approach with the computer and promoted the development of a conversational relationship. A user could now submit his own jobs, view the output on the terminal screen instead of waiting for a hard copy print, correct the errors if any, and resubmit the job. This type of computer/user interaction greatly increased the efficiency of the user and cost effectiveness in the use of digital computers.

The interactive display presented to the user on the terminal by the application program was usually of a type called scrolling. Scrolling is presenting a line of characters or text on the bottom of the terminal screen. This line moves upwards continually as new lines are presented. This type of presentation differs from natural reading techniques such as reading a book in that the material moves upward instead of the eyes moving downward across a steady display.

When using the scroll technique in data entry situations, the user is not aware of the next input requirements until it actually appears on the bottom of the screen. If errors occur while entering data, messages are displayed and scroll up while repeat prompts for user input are again requested by the program. Multiple occurrences of errors usually result in a screen full of scrolling error messages which often add to the confusion. Normally, scrolling interaction never allows a user to change a data entry once it is accepted by the program unless the user restarts the program (thus losing all previously entered data) or edits the data if the capability exists within the program.

In contrast, humanized form fillout display interaction closely simulates natural reading or viewing characteristics. All textural information or data entry requests are assembled in logically related groups to fit comfortably on "pages." These pages are presented to the user by clearing the CRT screen of all previous information before displaying the current "page." The text information is displayed starting at the top of the screen and proceeding downward until the bottom limit of the screen is reached. The user observes a stable screen of related information. In the case of data entry, related requests for user input are displayed simultaneously, enabling the user to foresee subsequent data entry requests. The cursor, which can be described as a small rectangular beam of light or pointer that emits characters on the screen, moves down the screen after each input request is satisfied.

This cursor movement is the key to powerful screen interaction. A typical terminal screen can be visualized as a matrix containing 24 lines by 80 columns or 1920 elements. These elements are individually addressable by programmed movement of the cursor to the selected element. Textural sequences can be displayed anywhere on the screen at any time while retaining or erasing previous information. This allows warning signals or error messages to appear next to the data in question and disappear after the error has been corrected leaving the original page of displayed information intact (see Figure 3). Another powerful use of cursor movement is in the case of data entry on a page affecting the allowable values of subsequent data entries on the same page. The allowable values displayed under a subject data entry prompt can be cursor addressed, changed to new values, and the cursor returned to the previous selection instantly. This method employs full conversational awareness by the computer system at all times, and differs from other techniques that "disconnect" the system with the terminal until a full page of user data is filled out. This later method is called buffered form fill out because the system is not aware of anything that is entered on the screen until the entire page is returned for processing. This method is better than scroll but not nearly as effective as the C/P interactive method in discussion.

Since the viewing displays are constructed in "pages," the user can manipulate the pages by a set of understandable interaction commands listed in the following:

1) TOP: request to clear the screen, redisplay the page, and return the cursor to the first input request on the current page. This permits modification of data on that page.

2) BACK: returns to the previous page for corrections or changes.

3) MAIN: terminates the program process in progress, manipulates computer files as needed, and returns to the main program menu of available processes.

4) EXIT: terminates the program process in progress, closes all computer files as needed, and exits the program.

User directed page movements, coupled with the dynamic display attributes attained through programmed addressable cursor movements, provide a powerful and flexible interactive environment for experienced as well as first time computer program users.

CONSIDERATIONS FOR INTERACTIVE COMPUTER SOFTWARE

An important consideration for selecting an interactive design method is compatibility among various computer hardware. Unfortunately, wide differences still exist between manufacturers of peripheral devices such as terminals and computer resident system programs called operating systems. Developing an interactive design methodology that is dependent upon a particular type of hardware or the operating system of a certain computer generally promotes the eventual demise of the approach. The constant change of operating systems due to computer vendor upgrades may render the programming required to accomplish such a design incompatible with the revised system.

More likely to occur, is the typical change or upgrades of CRT devices or terminals which may not accommodate some of the interactive features programmed for the previous device. ıe hardware or operating system dependent functions can be justified in the case where the application software and hardware are bundled together to form a functional package. These types of packages normally deal with graphics applications such as CAD/CAM systems or elaborate word processing systems. The special purpose computers are mostly self-contained systems requiring certain hardware and operating system configurations.

An interactive design method has to merge comfortably with the major application systems that are already on the machine such as engineering, accounting information retrieval systems, and word processing.

In order to accomplish this task and maintain compatibility among a wide selection of terminals and operating systems, a certain subset or core group of interactive functions are developed which will perform all the major tasks of a humanized form filled interactive method. The basic functions that are compatible with over 90 percent of the terminal hardware and computer systems available today are:

1) absolute cursor addressing,
2) clearing the screen, and
3) ringing the bell.

Another requirement is the ability of the computer system to send out what is called control characters which excite these functions. Using these basic functions as building blocks, an tire sophisticated "humanized" interactive approach can be accomplished while still retaining compatibility across vendor lines. Changes in terminal control character sequences for various terminals are accomplished by an easily accessible hardware table contained within the interactive application driver routines or by table files. These tables map the function to the device. There are many other functions available in terminals such as highlighting or dimming of certain groups of text, flashing of warning messages, and split screening for multiple tasks. These functions are not normally available in all terminals and are usually reserved for the higher priced models. In addition, the particular code sequences to start and stop these functions are widely different. These functions are just extensions of the basic three required to develop such a user friendly system.

A well designed interactive system using the basic three functions of cursor addressing, clear screen, and bell satisfies fully the criteria required to produce a truly "humanized" interactive methodology.

DESCRIPTION OF INTERACTION TECHNIQUES

In order to best describe the C/P methods used by the authors, an example display will be presented which is a portion of the rational method hydrology software package for uthern California.

All C/P displays on the CRT are by means of form field displays rather than scroll. This serves several purposes, namely increased speed for data entry and data checking by the program, and a comfortable environment for the program user by reading a stable screen display rather than observing a constant upwards motion of readable lines such as occurs in scroll type displays.

The interaction used is analogous to tutor texts used in the classroom where the reader is questioned on each page of the text and a subsequent page is listed depending on the reader's answer. In the C/P display, the entire CRT is used to instantly display parameter tables, data entry prompts, allowable values on data entry used to control program equation validity, and program control commands.

Figure 3(A) shows a typical C/P display used in the rational method program. This "page" appears instantly in its entirety on the CRT screen. The given page is one of five pages which are employed in the initial subarea rational method analysis portion of the computer program. The total number of screens used in the rational method program exceeds 100.

From Figure 3(A), several C/P requirements are illustrated as follows:

1) For a sequence of questions, the page number and algorithm description appears at the top of the page.

2) All words are written in their entirely, with abbreviations avoided whenever possible. This aids in self-teaching.

3) All data entry units are given.

4) Allowable values are identified which limit the data entries to within reasonable quantities.

5) Should the agency manuals suggest criteria for data entry, this is included on the display.

6) A "FAILSAFE" line appears on the CRT screen for each page. This line is located at the same position on the screen for each page.

7) Below the failsafe line appears all program operating instructions. These instructions can be typed by the user at any time and will cause the program to respond instantly. All necessary computer file manipulation is accomplished interior of the program.

The CRT cursor (Figure 3A) locates where the data entry appears on the page as the user types in the various data values. Should a data entry error occur (e.g., data entry is not within the allowable values, or the number entered contains two decimal points, etc.), the program audibly notifies the user by the bell and displays the error type above the failsafe line; then, the program reprompts the user for a correct entry. Figure 3(B) shows an error message display for an incorrect data entry. Figure 3(C) shows the C/P display after the user enters acceptable data for the error shown on Figure 3(B).

Figures 3(A, B, C) illustrate how the C/P page remains on the CRT screen with only cursor movement occurring, and/or error messages appearing and erased off the form field.

APPLICATION

Hydrology computer software based on the discussed interaction principles was recently used to prepare a master plan of drainage for several cities including the City of Ontario, California. The hydrology methodology used is the well known rational method with variable rainfall intensity duration and runoff coefficient relationships. The computer program is written in Fortran IV and consists of a highly optimized code of over 8000 lines of source. The entire program system, including editing capabilities, is contained on two 5¼-inch floppy discs for the Apple II–PLUS microcomputer. Data for the entire city master plan (population 90,000) is stored on four floppy discs. Although the computer program system is extremely complicated, no formal training was required for the program users. Additionally, no "user's manuals" were necessary due to the CRT presentation and interactive techniques employed.

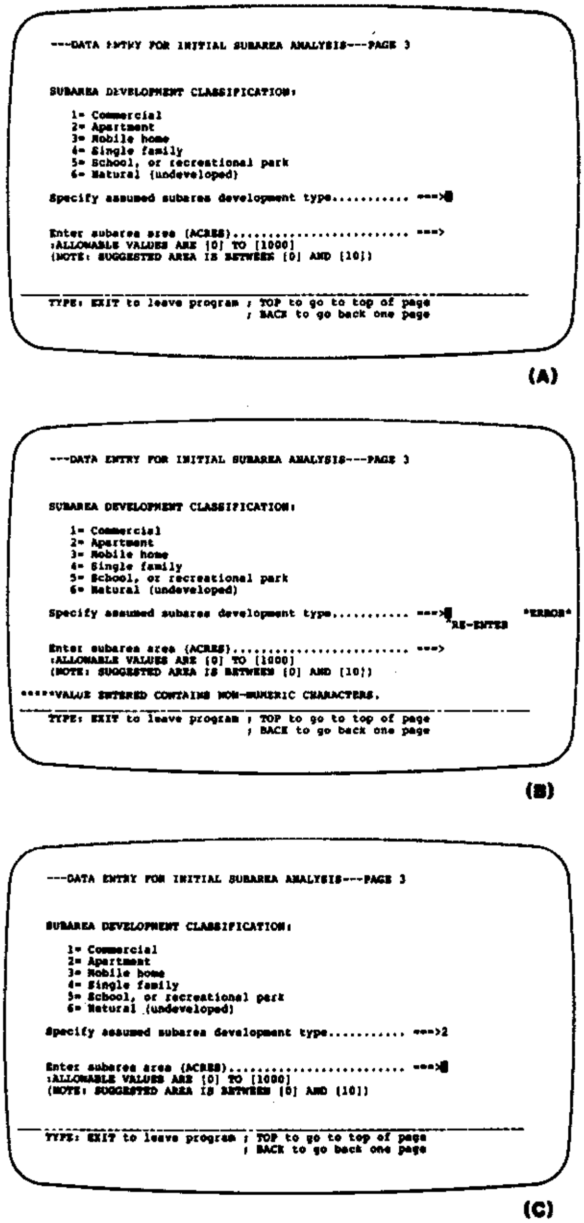

Figure 3. Example C/P Display for a Rational Method Program Showing (A) CRT Cursor, (B) Error Message Display, and (C) C/P Page Correction.

SUMMARY

Guidelines for the preparation of humanized computer software are presented. The techniques presented provide an application of state-of-the-art programming techniques to water resources engineering programming needs. By establishing a uniform user friendly set of programming guidelines at an agency or firm, the program training expenditure associated with new program users is minimized. Additionally, errors in program usage is virtually eliminated due to the ease of program use. The techniques provided are employable on most computers of the mainframe and minicomputer classes, as well as many currently available microcomputers. Generally, no formal training is required for program use, and no program user's manuals are needed.

Since water resources related studies and design problems generally involve significant computational effort with multiparameter models, the capability to conduct several studies exploring various design alternatives or model parameter sensitivity is needed. However, by using humanized software the costs of such iterative studies is significantly reduced. For example, a Southern California runoff hydrograph procedure generally costs about 40 man-hours of a hydrologist's time. Using humanized programming, a hydrograph can be developed in less than 10 minutes time. Consequently, water resources firms should explore and incorporate a standard humanized software plan into their company software development program.

LITERATURE CITED

Orange County Environmental Management Agency, 1978. Hydrology Manual.

Riverside County Flood Control and Water Conservation District, 1978. Hydrology Manual.

San Bernardino Flood Control, 1972. Hydrology Manual.

San Diego County Dept. of Public Works and Flood Control, 1975. Hydrology Manual.

Spence, J. D. and B. E. Larock, 1979. Interactive Computer-Aided Hydraulic Design: Culverts. *Water Resources Bulletin* 15(4):1153-1158.