3-1983

Evaluation and accessing of data for a water resources simulator

R. C. Peralta
Utah State University

Roberto Arce

Timothy Skergan

Follow this and additional works at: https://digitalcommons.usu.edu/cee_facpub

Part of the Civil and Environmental Engineering Commons

Recommended Citation
EVALUATION AND ACCESSING OF DATA FOR A WATER RESOURCES SIMULATOR

Richard C. Peralta
Roberto Arce and
Timothy Skergan

Agricultural Engineering Dept. University of Arkansas

Publication No. 91
March, 1983

Research Project Technical Completion Report A-060-ARK

Arkansas Water Resources Research Center
University of Arkansas
Fayetteville, Arkansas 72701

Arkansas Water Resources Research Center

Prepared for
United States Department of the Interior
EVALUATION AND ACCESSING OF DATA
FOR A WATER RESOURCES SIMULATOR

Richard C. Peralta
Roberto Arce, and Timothy Skergan
Agricultural Engineering Department, University of Arkansas
Fayetteville, Arkansas 72701

Research Project Technical Completion Report
Project A-060-ARK

The work upon which this report is based was supported in part by federal funds provided by the U. S. Department of the Interior, as authorized under the Water Research and Development Act of 1978, (P. L. 95-467).

Arkansas Water Resources Research Center
University of Arkansas
223 Ozark Hall
Fayetteville, Arkansas 72701

Publication No. 91
March, 1983

Contents of this publication do not necessarily reflect the views and policies of the U. S. Department of the Interior, nor does mention of trade names or commercial products constitute their endorsement or recommendation for use by the United States Government.

The University of Arkansas, in compliance with federal and state laws and regulations governing affirmative action and non-discrimination, does not discriminate in the recruitment, admission and employment of students, faculty and staff in the operation of any of it's educational programs and activities as defined by law. Accordingly, nothing in this publication should be viewed as directly or indirectly expressing any limitation, specification or discrimination as to race, religion, color or nation origin; or to handicap, age, sex or status as a disabled Vietnam-era veteran, except as provided by law. Inquiries concerning this policy may be directed to the Affirmative Action Officer.
ABSTRACT
EVALUATION AND ACCESSING OF DATA FOR A WATER RESOURCES SIMULATOR

This report evaluates the availability of data needed to use a groundwater simulation model for real time conjunctive water management in the Arkansas Grand Prairie. It is assumed that the goal of such management is to protect existing groundwater rights by maintaining water levels so that wells do not go dry, even in time of drought.

Sufficient hydrogeologic data exists to use the simulation model to predict the effect of known pumping rates on groundwater levels. Developing an optimal set of "target" levels and annually managing pumping to achieve those levels requires additional data: fall groundwater levels, degree of connection between aquifer and recharge streams, and annual cell by cell prediction of aquaculture and irrigated agriculture acreages. Successful management also requires continuous monitoring in the critical area where saturated thicknesses are small.

Peralta, Richard C., Roberto Arce and Timothy Skergan
EVALUATION AND ACCESSING OF DATA FOR A WATER RESOURCES SIMULATOR
KEYWORDS--data collections/ monitoring/ data acquisition/ well data/ groundwater management

*****************************************************************************
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction &amp; Objectives</td>
<td>1</td>
</tr>
<tr>
<td>Procedure and Results</td>
<td>2</td>
</tr>
<tr>
<td>Determination of Data Needs</td>
<td>2</td>
</tr>
<tr>
<td>Evaluation of Available Data Bases and Development of Software for Data Utilization</td>
<td>4</td>
</tr>
<tr>
<td>Conclusion and Recommendations</td>
<td>7</td>
</tr>
<tr>
<td>Appendices</td>
<td>11</td>
</tr>
<tr>
<td>Appendix A: Procedure to Estimate 1983 Agricultural Pumping in Cell M, County A</td>
<td>12</td>
</tr>
<tr>
<td>Appendix B: Sample Application for Aquaculture Permit</td>
<td>13</td>
</tr>
<tr>
<td>Appendix C: Program Which Estimates Cell by Cell Water Needs</td>
<td>14</td>
</tr>
<tr>
<td>Appendix D: Sample Report of Water Well Construction</td>
<td>25</td>
</tr>
</tbody>
</table>
INTRODUCTION AND OBJECTIVES

Arkansas established a Water Code Commission to make recommendations for legislation and rules concerning how Arkansas' water resources should be managed. An option which gained considerable support is the establishment of sub-state water management districts. The Grand Prairie of Arkansas represents a possible prototype water management district. The Arkansas Soil and Water Conservation Commission funded the calibration of a groundwater simulation model for the Quaternary aquifer underlying the Grand Prairie (13). This report supplements that effort by determining data needs appropriate for using the simulator for management.

In this report groundwater management refers to those acts which are necessary: to protect existing water rights by preventing water levels from dropping so much that wells go dry, or to assure the long-term adequacy of the water supply, even in times of drought. The authors assume that the water users themselves should decide if the latter goal is appropriate or desirable. With this in mind, the objectives of this study are to:

1) Determine data needs for the effective utilization of a groundwater simulation model for the Grand Prairie Quaternary aquifer.

2) Develop appropriate procedures to access available data bases.

3) Make recommendations for additional data needs.

The approach is first to report what data is needed for the effective use of the simulation model. Available data and data
bases are subsequently evaluated concerning suitability in meeting data needs. Software and/or procedures to retrieve appropriate data are presented. Finally, recommendations for additional data needs are made.

PROCEDURE

Determination of Data Needs

It is judged desirable to make groundwater management as administratively simple as can be successful. Probably, the period of pumping which a water agency can most readily manage is one year. In other words the agency can, using the simulator, determine how much water can be pumped out of each part of the Prairie in one year's time to meet the area-wide goals of the water users. In practice, the agency will regularly determine whether actual resulting water levels do indeed agree with predictions. Adjustments in permitted pumping may be made as the resources, goals, or needs of the users change.

The user-related data needed for this purpose are estimates of the water requirements in each 3 mile by 3 mile cell of the study area, as affected by climatological conditions. The necessary hydrogeologic information includes:

- effective porosity and hydraulic conductivity of the aquifer (including spatial variations, if significant).
- elevations of the top and bottom of the aquifer material.
- spring and fall elevations of the groundwater level.
- degree of connection between the aquifer and streams which serve as recharge or discharge sites.

At the very least, groundwater levels must be measured annually (in the spring) over the entire area. The USGS has historically made annual measurements in the spring (8,16). Continuity of records must be preserved. It is preferable, however, to make the area-wide measurements on a semi-annual basis (spring and fall).

The most important reason for this is that almost all the water is pumped during the summer. Simulation verified every spring and fall could provide more accurate information on the next year's permitted pumping than simulation verified only in the spring. That information would also be available six months earlier. A third reason is that recharge into the study area from its periphery depends largely on the hydraulic gradient from the recharge source towards the area interior. The only estimates of the gradient currently available are those in the spring. At that time the rivers which border and recharge the area are at their highest stage and the aquifer has recovered, as much as it will have opportunity to, from the previous summer's pumping. It is important to know also what the gradient is like in the fall, when recharge streams are at low stage and aquifer water levels have not recovered much from the summer's pumping. Estimates of the degree of connection between the aquifer and penetrating streams are needed to permit approximation of the maximum feasible recharge to or discharge from the aquifer.
Measurements more frequent than semi-annual, over the entire area, would provide little useful information, since the effect of pumping wells during the summer distorts the water levels in their proximity. The process of compensating for that effect to estimate average water levels in the summer would be too time consuming to be justified.

The preceding paragraphs have addressed the necessary data for determining annual permitted pumping volumes. This volume/year flowrate, since it is simple, is necessarily fairly "crude." The temporal distribution of pumping during the summer by independent users can only be estimated. Therefore, resulting summertime saturated thicknesses in some parts of the area could be less than anticipated. For this reason more frequent observations should be made in that part of the study area where saturated thicknesses are critically small. Weekly, daily, or possibly continuous observation and subsequent management action may be necessary to prevent the litigation which can result when wells go dry. Such monitoring also provides a check on the simulation model. This check is needed since no model of an area the size of the Grand Prairie is a perfect predictor.

Evaluation of Available Data Bases and Development of Software for Data Utilization

Predicted water needs for an upcoming year (on a cell by cell basis) are not available in any existing data base. They may,
however, be estimated. The water need for irrigable crops and given climatological conditions (7) can be approximated using a daily simulated water balance. Appendix A contains a procedure which uses the resulting crop water needs, the USGS's 1972 RIDS data base (2,11,12,14) and projected crop acreages to estimate annual water needs for each cell.

The Crop Reporting Service is the most likely source of anticipated acreages (1). An additional source of general information on water use is the excellent periodic water use summary prepared by the USGS (17,18). A more accurate means of estimating the acreages of irrigated crops in each cell is desirable.

Adequate estimates of municipal use of Quaternary groundwater can be made from data in the Arkansas State Water Plan (4). Estimates of aquacultural acreage in each cell can be made from the State Water Plan (3), and records of the Arkansas Fish and Wildlife Service (see Appendix B). It is a common opinion among extension agents that there are thousands of acres of unreported aquaculture. The annual water needs of aquacultural activities range from 3-8 acre-ft/acre. Accordingly, accurate knowledge of aquacultural water needs are important for any management effort.

A simple program was written which sums agricultural, aquacultural and municipal water needs and estimates the pumping from the Quaternary aquifer on a cell by cell basis (Appendix C). Probably, water needs are greater than permissible pumping under
most desirable management strategies. Therefore, an alternative source of water will probably be needed. The physical availability of divertable surface water from the Arkansas or White Rivers can be determined using USGS streamflow records (19).

Several USGS reports (6,10,14) cite estimates of effective porosity or hydraulic conductivity. A review of these is found in a recent report by Peralta, et al. (13). Estimates of the top and bottom of the Quaternary aquifer are found in existing maps (5,9). They may also be created using data from Reports of Water Well Construction (Appendix D) which are filed with the state. These reports contain useful information on the formation, type of water user, well characteristics, etc. The Soil Conservation Service also has a comprehensive listing of wells and surface water diversions. Spring elevations of the piezometric surface are available from USGS reports (8,16). Fall elevations are not available. Standard programs are available on most computer mainframes to grid random three-dimensional observations. Sample procedures include polynomial fitting, spline fitting, and universal kriging. Such programs are used to prepare gridded estimates of the saturated thickness of the aquifer from the data discussed above.

1 It would aid groundwater protection and management in the state if information concerning all strata and their color, and the quarter section in which the well is located were included in all such reports.
Until recently, one well in the Grand Prairie's Quaternary aquifer was continuously monitored. Encrustation of the well ended its usefulness. A new monitoring station has not yet been established (possibly for economic reasons). Continuous monitoring site(s) need to exist in that part of the Prairie where saturated thicknesses are smallest. Preferably, data from the site(s) would be retrieved weekly or as collected (by telemetry). Determination of the number of continuous monitoring sites requires prediction of the effect of future pumping strategies and is beyond the scope of this report.

Estimates of the degree of connection between aquifer and penetrating stream are not available.

CONCLUSIONS AND RECOMMENDATIONS

A program has been written which estimates cell by cell water needs based on available data bases. However, no data base accurately reflects the acreage of irrigated cropland or aquaculture which will probably exist in each cell in the next year. This is an important need. The availability of such information would enable the water management agency better to fill water needs with available groundwater and diverted surface water resources.

Sufficient data is available to estimate the effect of different pumping strategies on future Quaternary groundwater availability in the Grand Prairie. Thus regional pumping strategies can
be developed using a calibrated simulation model (13) and existing data bases. Optimizing or successfully using such strategies will require some additional information.

For most of the Grand Prairie, only spring water levels are currently being measured. This means that a management agency can determine the effect of its management strategy only after every spring. This provides inadequate lead time for determining the subsequent summer's groundwater withdrawal strategy. Thus it is recommended that observations be made in the fall as well as in the spring for all sites currently being annually monitored. It is also suggested that continuous monitoring be used in areas where saturated thicknesses are critically small. The resulting data should be retrieved and analyzed regularly to protect against unexpected dewatering.

The degree of connection between penetrating streams and the aquifer is currently unknown. This should be determined to permit estimation of maximum feasible recharge and the effect of groundwater pumping on the downstream availability of surface water.
BIBLIOGRAPHY


2) Arkansas County Profile. Little Rock, AR: Arkansas Department of Local Services, 1977.


5) "Bottom of Pleistocene, Grand Prairie Rice Region." Confidential Map, Federal Land Bank of St. Louis, MO, 1936.


9) "Elevations of Top of Water Bearing Sand (Shallow Wells)", Unpublished Map, Agricultural Engineering Department, University of Arkansas, Fayetteville.


BIBLIOGRAPHY (con't)


19) Water Resources Data for Arkansas Water Year 1977 (and other years). USGS Water-Data Report AR-77-1. Little Rock, AR.
APPENDIX A

Procedure to Estimate 1983 Agricultural Pumping in Cell M, County A

ACRE (M) = the agricultural acreage in cell M in 1972 (ac)

TAGAC (A) = the total agricultural acreage in county A within the study area in 1972 (ac)

RAGA (A,83) = the expected rice acreage in county A within the study area in 1983 (ac)

SAGA (A,83) = the expected soybean acreage in county A within the study area in 1983 (irrigated) (ac)

RIR (83) = irrigation water used for rice irrigation in average years *

SIR (83) = irrigation water used for soybean irrigation in average years *

QUAT (A) = the percent of the county's irrigation water which is drawn from the Quaternary aquifer

Z (A,83) = RAGA (A,83) x RIR (83) + SAGA (A,83) x SIR (83)

= total expected water need for rice and soybean irrigation in county A in 1983 (ac-ft)

AGPUMP (M,83) = Z (A,83) x \frac{ACRE (M)}{TAGAC (A)} x QUAT (A)

= the volume of water need expected for rice and soybean irrigation in cell M in 1983 (ac-ft) which is pumped from the Quaternary aquifer

* The irrigation water used for rice and soybean irrigation was computed by daily water balance simulation.
COMPUTATIONS

DO 400 N1=1,10
   DO 375 L1=1,10
   RAX(N1,L1)=RAGA(N1,L1)*RIP(N1,L1)
   RAY(N1,L1)=SACA(N1,L1)*SIP(N1,L1)
   CAXY(N1,L1)=(0.024)*RAX(N1,L1)+RAY(N1,L1)
   CAYR(N1,L1)=CAXY(N1,L1)*12.00

375 CONTINUE

DO 400 N1=1,10
   DO 375 L1=1,10
      IL=NLJFLF(I)+1
      IF(EO,NO,IL)=NLJLEFT(I)+1
      IF(EO NIL)=1
      DO 400 J1=1,IL
         L1=ICOUN(I,J1)
         P(N1,I,J1)=(ACRE(I,J1)*247.11)*RAX(N1,L1)*SHEW(L1)*RMAH(I,J)
         P(N1,I,J1)=P(N1,I,J1)+ANACUA(N1,J1)+(1.0)
         IF(EO NIL)=1
      DO 375
      CONTINUE

PR(N1,I,J1) IS THE PUMPING IN ACRE FEET
P2(N1,I,J1)=P(N1,I,J1)*43560.

PA(N1,I,J1) IS THE PUMPING IN FEET PER CELL
PA(N1,I,J1)=3*(ACRE(I,J1)*440.840/9.

PP(N1,I,J1) IS THE AGRICULTURAL PUMPING IN ACRE FEET
PP(N1,I,J1)=(ACRE(I,J1)*247.11)*CAXY(N1,L1)*SHEW(L1)

PC TOTAL IS PS
PS(N1,L1)=ALNE(I,J1)*247.11*RAX(N1,L1)*SHEW(L1)*P5(N1,L1)

SOYBEAN TUNAL IS PS
PS(N1,L1)=ALNE(I,J1)*247.11*RAX(N1,L1)*SHEW(L1)*TAGAC(L1)*PS(N1,L1)

AQUACULTURAL PUMPING (INITIAL INPUT) IS TAGI(N1,L1)
TAGI(N1,L1)=ANACUA(N1,J1)*TAGII(N1,L1)

AQUACULTURAL PUMPING (ADDITIONAL INPUT) IS TAGII(N1,L1)
TAGII(N1,L1)=ANACUA(N1,J1)*TAGII(N1,L1)
THE CELL NUMBERS FOR READING IN THE MUNICIPAL WATER USE ARE THE I AND J VALUES

DO 360 NUM=1,9
READ(S,0)K[I,J]
READ(S,0)MUKA(I,J)
CONTINUE

READ IN THE VALUE FOR THE TOTAL AQUACULTURAL WATER REQUIREMENT (BY CELL NUMBER AS ABOVE) THIS NUMBER WILL BE MULTIPLIED BY 0.4 BECAUSE 90% OF THE WATER COMES FROM THE QUATERNARY AQUIFER. ******** (AC. FT.)

DO 360 NUM=1,24
READ(S,0)K[I,J]
READ(S,0)ADAKA(I,J)
ADAKA(I,J)=0.9*ADAKA(I,J)*1,00
CONTINUE

ADDITIONAL INPUT (RECHARGE & AQUACULTURE)

ADAKA(K,I,J) ADDITIONAL AQUACULTURAL PUMPING (AC. FT.)
K IS THE YEAR

EMPERC(I,J) EMPRICAL RECHARGE CONSTANT (CUBIC FT./YEAR X 10 TO THE 7TH.)

DO 365 NUM=1,12
READ(S,0)I,J,FEMP(I,J)
EMPERC(I,J)=FEMP(I,J)*10**7
CONTINUE

DO 367 NUM=1,17
READ(S,0)I,J,ADAKA(K,I,J)
ADAKA(K,I,J)=ADAKA(K[I,J],I,J)*1.80
DO 366 MY=7,10
ADAKA(MY,I,J)=ADAKA(K,I,J)
CONTINUE.

CONTINUE
READ IN THE IRRIGATION REQUIREMENTS FOR RICE FOR EACH YEAR (IN.)
DO 190 N=1,10
READ(R,I)IR(N)
190 CONTINUE

READ IN THE IRRIGATION REQUIREMENTS FOR SOYBEANS PER YEAR (IN.)
DO 190 N=1,10
READ(S,I)IR(N)
190 CONTINUE

READ IN THE COUNTY THAT EACH CELL IS IN
DO 200 I=2,21
[I,J]=LEFT(I,J)
[T]=P10W(I,J)
READ(S,T)(COUN(I,J),J=1,17)
200 CONTINUE

READ IN THE AGRICULTURAL AREA IN EACH CELL (SQUARE KM.)
DO 210 I=2,21
[I,J]=LEFT(I,J)
[T]=P10W(I,J)
READ(S,T)(ACRE(I,J),J=1,17)
210 CONTINUE

READ IN THE PERCENTAGE OF AGRICULTURAL WATER COMING FROM
PUMPING UP THE QUaternARY aquifer
READ(S,T)(SHME(L),L=1,4)

READ IN THE MUNICIPAL WATER USE BY LOCATION (AC.-FT.)
AD 00970
AD 00980
AD 00990
AD 01000
AD 01010
AD 01020
AD 01030
AD 01040
AD 01050
AD 01060
AD 01070
AD 01080
AD 01090
AD 01100
AD 01110
AD 01120
AD 01130
AD 01140
AD 01150
AD 01160
AD 01170
AD 01180
AD 01190
AD 01200
AD 01210
AD 01220
AD 01230
AD 01240
AD 01250
AD 01260
AD 01270
AD 01280
AD 01290
AD 01300
AD 01310
AD 01320
AD 01330
AD 01340
AD 01350
AD 01360
AD 01370
AD 01380
AD 01390
AD 01400
AD 01410
AD 01420
AD 01430
AD 01440
DATA ENDS/C/46P*0.0/

READ STATEMENTS

BOUNDARIES -- FOR ENTIRE MODEL --
DO 100 I=1,21
READ(5,6) JLEFT(I), JRIGHT(I)
100 CONTINUE

BOUNDARIES FOR SUBSET MODEL
FIRST PERFORM A NULL READ ON ABSURD NUMERICAL DATA
UU 110 I=1,22
READ(5,6) JLEFT(I), JRIGHT(I)
CONTINUE

NOW READ THE LIMITS OF THE SUBSET OF THE GRAND PRAIRIE
FOR THE APPLICATION RUN TO BE PERFORMED BY ANHISIN
DO 112 I=1,22
READ(5,6) JLEFT(I), JRIGHT(I)
112 CONTINUE

READ IN THE TOTAL ACREAGE FOR EACH COUNTY (AC.)
READ(5,6) TAGAC(L), L=1,4
150 CONTINUE

READ IN THE ACREAGE OF IRRIGATED RICE (AC.)
DO 160 N=1,10
READ(5,6) RAGA(N), L=1,4
160 CONTINUE

READ IN ACREAGE OF IRRIGATED SOYBEAN (AC.)
DO 170 N=1,10
READ(5,6) SAGA(N), L=1,4
170 CONTINUE

APPENDIX C (Continued)
NAME: ADSIMPUM FORTRAN A

Calculates the amount of pumping from the Quaternary Aquifer in the Grand Prairie region, only considering rice and soybean acreage (reported for each county).

DATA REQUIRED IS IN:
--ADSIMPUM DATA A--

The file to execute this program is under the name of
--ADSIMPUM EXEC A--

DIMENSION LEFT(26), RIGHT(26), FEMP(26*18)
DIMENSION NLEFT(26), NRIGHT(26)
DIMENSION NULL(26), NWR(26)
DIMENSION RAGA(10,4), SHNE(4)
DIMENSION RAGB(10,4), SABA(10,4), PIR(10), SIR(10)
DIMENSION ICOUN(26,18), ACRE(26,18), RMWA(26,18)
DIMENSION PAGA(26,14)
DIMENSION PAQU(10,4), RHY(10,4), CAXPY(10,4), SUM(10,4)
DIMENSION SUMT(10), GM(10,2*10), PS(10,2), PB(10,2)
DIMENSION TAGA(10,4), TAGB(10,4), TAGC(10,4)
DIMENSION ADAQUA(10,26,18)
DIMENSION EMPREC(26,18)

DATA GN/400*0/,
DATA FEMP/400*0/.
DIMENSION TP(10,4)
DIMENSION PA(10+26+18), P2(10+26+18), P3(10+26+18)
DIMENSION PA1(10+26+18)
DIMENSION ON(10,30,8)
DIMENSION TR/400*0/, SABA/400*0/, RIR/10*0/, SIR/10*0/
DATA RAY/400*0/, CARRY/400*0/, SUM/400*0/
DATA PA/400*0/, PM/400*0/, SP/400*0/, TP/400*0/, TAG1/400*0/
DATA ACRE/400*0/, RMWA/400*0/, TR/400*0/
DATA RAY/400*0/,
DATA GN/24000*, GM/24000*, P2/46800*,
DATA PC/46800*, P4/46800*,
DATA ICOUN/4680*, SHAWAC/4680*.
**APPENDIX B**

*Please estimate production acres so that we can assist you in planning by establishing changing trends in fish farming.*

<table>
<thead>
<tr>
<th>SPECIES OF FISH</th>
<th>ACRES - 1978</th>
<th>ACRES PLANNED - 1979</th>
</tr>
</thead>
<tbody>
<tr>
<td>Golden Shinner</td>
<td>25</td>
<td>40</td>
</tr>
<tr>
<td>Fathead Minnows</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Catfish (Food) (Brood)</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Catfish (Fingerling)</td>
<td>315</td>
<td>315</td>
</tr>
<tr>
<td>Goldfish</td>
<td>15</td>
<td>25</td>
</tr>
<tr>
<td>Trout</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (Specify)</td>
<td>White Am</td>
<td>40</td>
</tr>
<tr>
<td>*Total Acres</td>
<td>400</td>
<td>400</td>
</tr>
</tbody>
</table>

Lonoke

Enclosed is check of $25.00 for 1979 renewal of Fish Farmer Certificate Number 220.

Bullfrog Permit Number

$25.00 Dec 5 '78

Signature of owner or agent

Address if changed

(please print)
TOTAL AQUACULTURAL PUMPING IS \( TAO(N+L) \)
\( TAO(N+L) = ADAUAI[I+J] + ADAUAI[N+I+J] + TAO(N+L) \)
TP(N,L) IS THE PUMPING FOR THE COUNTY
TP(N,L) = P[N+I+J]
SUM(N,L) IS THE TOTAL PUMPING FOR EACH COUNTY
SUM(N,L) = SUM(N+L) + TP(N,L)
CONTINUE
SUM(N) IS THE TOTAL PUMPING FOR THE YEAR (ACRE FEET)
SUM(N) = SUM(N) + SUM(N,L)
CONTINUE
THE NEXT THREE STATEMENTS ADDED 3/3/83,
THEY ADD RESPONSE TO THE THREE CELLS INCLUDED.
THE RECHARGE IS THE AVERAGE OF THE STEADY STATE PUMPING VALUES
FROM THE OUTPUT OF 11/15/82.
\( P[N+1,1] + P[N+1,11] + 61355000 \)
\( P[N+1,1] + P[N+1,11] + 61355000 \)
\( P[N+1,1] + P[N+1,11] + 61355000 \)
CONTINUE

*** This next part was added to write out the pumping in a format which simula must read it ***
DO 560 N=1,10 IC=1
DO 570 I=1,22 JJ=JULFF(I)
BB=MNNJ(I)
DO 560 JJ=J,L,L,0
ON(N,10)+ON(N+1,10)
WRITE(6,947)(IC=PON(N,10))
IC=IC+1
CONTINUE
570 CONTINUE
560 CONTINUE
DO 560 N=1,10 IC=1
DO 570 I=1,26 IK=I+1
DO 560 J=1,8 IC=IC+1
ONF[N+1,IC]=ON[N+1,IC]
WRITE(10,948)(IC=ONF[N+1,IC])
CONTINUE
560 CONTINUE
CONTINUE
DO C00 H=1,10
DO C07 I=1,26
WRITE (7+Y04)(MNF(N,I,J),J=1,8)
CONTINUE
CONTINUE

********************

**WRITING OUT THE SUM OF THE PUMPING FOR EACH COUNTY BY YEAR**
**FOR THE TOTAL PUMPING, THE PUMPING FOR VICE IRIGATION,**
**AND THE PUMPING FOR SOYBEAN IRRIGATION**

DO C00 K2=1,6
IYEAR=1971
IF (K2,EQ,0) GO TO 608
IF (K2,EQ,2) GO TO 605
IF (K2,EQ,4) GO TO 601
IF (K2,EQ,6) GO TO 604
WRITE (6,911)
GO TO 612
600 WRITE (6,911)
GO TO 612
602 WRITE (6,912)
GO TO 612
604 WRITE (6,914)
GO TO 612
606 WRITE (6,916)
GO TO 612
608 WRITE (6,918)
WRITE (6,919)
NO A=1, N=1,10
IYEAR=IYEAR+1
IF (K2,EQ,0) GO TO 617
IF (K2,EQ,2) GO TO 615
IF (K2,EQ,4) GO TO 613
IF (K2,EQ,6) GO TO 614
WRITE (6,960)(IYEAR,(SUM(N,L) L=1,4)*SUMT(N))
GO TO 614
613 WRITE (6,960)(IYEAR,(P6(N,L) L=1,4))
GO TO 614
616 WRITE (6,960)(IYEAR,(P6(N,L) L=1,4))
GO TO 614

---

APPENDIX C
(Continued)
**APPENDIX C**

The next statements are only to create the same data into a file that can be use by SAS.

DO 790 N=1,10
DO 690 L=1,4
WRITE(A940)N,L,SUM(N,L)

CONTINUE

**THIS PART ADDED 8/25/82 TO WRITE THE WATER USE IN MAP FORM**

**A**: AGRICULTURAL LAND, IN ACRES
DO 720 J=1,4
ACRE(I,J)=ACRE(I,J)*247.11
WRITE(I,J)
CONTINUE

**A2**: PUMPING DUE TO AGRICULTURE. ACRE-FT

791 FORMAT(3F15.4,2X,PUMPING DUE TO AGRICULTURE, ACRE-FT,3X,15,,/)
DO 720 N=1,10
IF (IYAP=17) N
WRITE(A940)IYAP
CONTINUE

*Note: The rest of the code snippet is not fully transcribed due to image quality and readability constraints.*
DO 730 I=1,27
    WRITE (6,731) (MUNICIPAL WATER USE, ACRE-FT)
    CONTINUE
730 FORMAT (2X*18F7.0/

C: MUNICIPAL WATER USE, ACRE-FT

WRITE (6,731)
731 FORMAT (111:20X*MUNICIPAL WATER USE, ACRE-FT,/) 
    DO 732 I=1,27
        WRITE (6,734) (MUNICIPAL WATER USE, ACRE-FT,/) 
    CONTINUE
734 FORMAT (2X*18F7.0/

C: AQUACULTURAL WATER USE, ACRE-FT

WRITE (6,741)
741 FORMAT (111:20X*AQUACULTURAL PUMPING, ACRE-FT,/) 
    DO 742 I=1,27
        WRITE (6,744) (AQUACULTURAL PUMPING, ACRE-FT,/) 
    CONTINUE
744 FORMAT (2X*18F7.0/

ADDITIONAL INPUT

WRITE (6,747)
747 FORMAT (111:10X*ADDITIONAL AQUACULTURAL PUMPING 1977-1981 ACREAD)

STOP

APPENDIX C
(Continued)
**APPENDIX D**

**STATE OF ARKANSAS**

**AERPORT**

**ST-1254**

**REPORT OF WELL CONSTRUCTION**

**Well No.** X \(^{1}\) Replacement Well

**Owner of Well** J. J. Jones

**Well Company** Layne Arkansas Company

**Contractor License No.** C-1099

**Driller Name and No.** Harvey Bullock = D-204

**Date Well was Completed** May 9, 1977

<table>
<thead>
<tr>
<th>Total Depth of Well</th>
<th>636'</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Producing Formation: From</td>
<td>550'</td>
</tr>
<tr>
<td>To</td>
<td>636'</td>
</tr>
<tr>
<td>Water Level Below Land Surface</td>
<td>134'</td>
</tr>
<tr>
<td>Gallons per Hour</td>
<td>7600</td>
</tr>
<tr>
<td>Water Disinfected with</td>
<td>HTH</td>
</tr>
<tr>
<td>Casing to</td>
<td>542'</td>
</tr>
<tr>
<td>Cased with</td>
<td>12&quot; Diameter 250' Casing</td>
</tr>
<tr>
<td>Cased from</td>
<td>0' to 542'</td>
</tr>
<tr>
<td>Use of Well: Domestic Irrigation Municipal Other</td>
<td></td>
</tr>
</tbody>
</table>

**Remarks:**

**Signed:** [Signature]  Date: 5/16/77

**Geology Copy**

<table>
<thead>
<tr>
<th>Rock Type</th>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Sandy Clay</td>
<td>35'</td>
</tr>
<tr>
<td>Red Clay</td>
<td>70'</td>
</tr>
<tr>
<td>Fine Sand</td>
<td>100'</td>
</tr>
<tr>
<td>Coarse Sand &amp; Gravel</td>
<td>136'</td>
</tr>
<tr>
<td>Gumbo</td>
<td>236'</td>
</tr>
<tr>
<td>Rock</td>
<td>244'</td>
</tr>
<tr>
<td>Gumbo</td>
<td>245'</td>
</tr>
<tr>
<td>Rock</td>
<td>280'</td>
</tr>
<tr>
<td>Gumbo</td>
<td>295'</td>
</tr>
<tr>
<td>Fine Sand &amp; Silts of Shale</td>
<td>369'</td>
</tr>
<tr>
<td>Gumbo</td>
<td>445'</td>
</tr>
<tr>
<td>Sandy Shale</td>
<td>522'</td>
</tr>
<tr>
<td>Gumbo</td>
<td>547'</td>
</tr>
<tr>
<td>Fine Sand</td>
<td>633'</td>
</tr>
<tr>
<td>Medium Sand</td>
<td>648'</td>
</tr>
<tr>
<td>Gumbo</td>
<td>670'</td>
</tr>
</tbody>
</table>

---

Footnotes:

\(^1\) Well is near 5 Township 25 Range 5W