SOFTWARE RELEASE NOTICE

01. SRN Number: **GHGC-SRN-187**

02. Project Title: **USFIC**	Project No.: **20-1402-861**
03. SRN Title: **AQTESOLV Version 2.12**	
04. Originator/Requestor: **James Winterle**	Date: **3/22/99**

05. Summary of Actions

- ■ Release of new software
- ☐ Release of modified software:
  - ☐ Enhancements made
  - ☐ Corrections made
- ☐ Change of access software
- ☐ Software Retirement

06. Persons Authorized Access

Name	Read Only/Read-Write	Addition/Change/Delete
J. Winterle	**RO**	**A**
A. Armstrong	**RO**	**A**
D. Farrell	**RO**	**A**
Others CNWRA Staff as Required	**RO**	**A**

07. Element Manager Approval: **English Pearcy** Date: 3/24/99

08. Remarks: **This is commercially available software. No source code is included.**

CNWRA Form TOP-6 (05/98)

SOFTWARE SUMMARY FORM

01. Summary Date: **3/22/99**	02. Summary prepared by (Name and phone) **James Winterle (210) 522-5249**	03. Summary Action: **NEW**
04. Software Date: **3/24/99**	05. Short Title: **AQTESOLV**	
06. Software Title: **AQTESOLV Version 2.12**		07. Internal Software ID: **NONE**

08. Software Type: ☐ Automated Data System ■ Computer Program ☐ Subroutine/Module	09. Processing Mode: ■ Interactive ☐ Batch ☐ Combination	10. Application Area a. General: ■ Scientific/Engineering ☐ Auxiliary Analyses ☐ Total System PA ☐ Subsystem PA ☐ Other b. Specific: **Aquifer Pumping Test Analyses.**
11. Submitting Organization and Address: CNWRA/SwRI 6220 Culebra Road San Antonio, TX 78228		12. Technical Contact(s) and Phone: **HydroSolve, Inc.**
13. Software Application: **Analyses of Aquifer pumping test.**		

14. Computer Platform **DOS/PC**	15. Computer Operating System: **Win NT**	16. Programming Language(s): **N/A**	17. Number of Source Program Statements: **N/A**
18. Computer Memory Requirements: **4 Mb**	19. Tape Drives: **N/A**	20. Disk Units: **N/A**	21. Graphics: **N/A**
22. Other Operational Requirements: **NONE**			
23. Software Availability: ■ Available ☐ Limited ☐ In-House ONLY		24. Documentation Availability: ■ Available ☐ Preliminary ☐ In-House ONLY Built in help function.	

25.

Software Developer: HydroSolve, Inc. Date: 3/24/99

Tested by: [signature] CNWRA QA 3/25/99

CNWRA Form TOP-4-1 (05/98)

Acceptance and Software Validation Testing
AQTESOLV, Version 2.12–Professional for TOP-18 Control

Description

AQTESOLV version 2.12 is produced and distributed by Hydrosolve, Inc. This software is commercially available and is used widely by hydrologist to perform analyses of aquifer pumping and slug tests. The software was delivered in a single diskette which contained the executable programs and documentation. The following is a description of software installation testing and validation in accordance with the requirements in table 1 of TOP-18 for commercially acquired software that is not to be modified.

Version and Documentation

AQTESOLV, Version 2.12–Professional was obtained from a commercial vendor, Hydrosolve, Inc., which is also the developer of the software. Documentation is provided in two ways: (i) and interactive help function, and (ii) in an Adobe .pdf file that is included in the software diskette. AQTESOLV is used for analysis of aquifer pumping test data and is well known and widely distributed among the hydrology community.

Acceptance and Validation Testing

The procedures given below were developed to comply with the requirements of TOP-18 for (i) acceptance testing, and (ii) software validation testing plan. These tests should be easily repeatable by any qualified hydrologist using only the information provided below and the attached figures.

To ensure that the software performs as advertized, three different validation tests were performed. First, the software was used to fit a Theis analytical solution for a confined aquifer to a data set representing an xy plot of the exponential-integral function (also known as the "well function" in hydrology circles). The software prompted me for inputs of well radius, aquifer thickness, and pumping rate: values of 1.0 were assigned to each. Expected output for this problem is an aquifer transmissivity estimate of $1/4\pi$ (0.7958) and a storage coefficient estimate of $1/\pi$ (0.318). As shown in figure 1, the output is as expected.

Second, a Neuman analytical solution for unconfined aquifers was used to fit the same exponential-integral function. The expected output depends on values chosen for parameters β and Sy, however if these values are very close to zero, the output should be the same as for the Theis solution described above. Values of 1E-10 were assigned to both β and Sy. As shown in figure 2, the output is as expected.

Third, a Moench analytical solution for fractured rock aquifers was tested. As there were no convenient data sets available with known outcomes, the original publication of Moench (1984) was used for a qualitative comparison. In that publication, Moench fits his solution to a data set and obtains aquifer parameters. For this test, the parameters obtained by Moench were input into

AQTESOLV and the resulting plot was qualitatively compared to the data set and model fit presented by Moench. Figure 3 shows the AQTESOLV output along with two plots from the Moench (1984) publication (taped to page). Visually, the output plot from AQTESOLVE is indistinguishable from the plot given by Moench.

Conclusion

True to its reputation, the AQTESOLV Version 2.12–Professional aquifer test analysis software provides accurate estimates of aquifer parameters for the cases tested. AQTESOLV software has many other capabilities that were not tested, e.g., analysis of slug tests. It would not be feasible to test every method of analysis, however, given the outstanding reputation of this analytical tool among the hydrology community, a high degree of confidence can be placed on the accuracy of analyses performed with this software.

Reference

Moench, A.F. 1984. Double porosity models for a fissured groundwater reservoir with fracture skin. *Water Resources Research 20* (7): pp 831–846.

Software Acceptance and Validation Testing
AQTESOLV, Version 2.12–Professional for TOP-18 Control

Software Category: Acquired; Not to be Modified

Purpose: This document is intended to document the Software Installation Testing, and the Software Validation Test. There is no need for a separate software validation test plan because a description of the Software Validation Test is provided along with the test results. The TOP-18 requirements for a Software Validation Test Plan are included in the validation test results.

A. Acceptance Testing (Installation Testing Only)

Installation testing consisted of inventorying the software provided, installing the software according to the instructions provided, and ensuring that the software can be successfully launched form the Windows NT platform. The software was provided on a single 3.5 inch diskette. A backup copy was made for records and the original was given to IMS staff for storage. Documentation and user's instructions for the software are provided through the Help menu once the software is installed and launched. The installation test was successful with no installation problems encountered.

B. Validation Test Plan and Test

1.0 Scope of the Validation

The validation testing considers three of the most commonly used analytical solutions for aquifer pumping test interpretation: (1) The Theis (1935) confined aquifer solution; (2) the unconfined aquifer solution of Neuman (1975); and (3) the Moench (1984) dual-porosity aquifer solution. The scope of the test cases discussed below demonstrate the ability of the software to: (1) read input time-drawdown data from a theoretical observation well; (2) fit an analytical solution to the time-drawdown data, in the form of a response curve; and (3) accurately estimate the aquifer parameters relevant to the analytical solution.

2.0 References

Moench, A.F. 1984. Double porosity models for a fissured groundwater reservoir with fracture skin. *Water Resources Research 20* (7): pp 831–846.

Neuman, S.P. Analysis of pumping test data from anisotropic unconfined aquifers considering delayed gravity response. *Water Resources Research* (11)2: 329–342. 1975.

Theis, C.V. The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using ground-water storage. *American Geophysical Union Transactions* 16: 219–524. 1935.

3.0 Environment
3.1 Software

AQTESOLV, Version 2.12–Professional was obtained from a commercial vendor, Hydrosolve, Inc., which is also the developer of the software. Documentation is provided in two ways: (i) interactive help function, and (ii) in an Adobe pdf file that is included in the software diskette. AQTESOLV is used for analysis of aquifer pumping test data and is well known and widely distributed among the hydrology community. AQTESOLV Version 2.12 Professional is produced and distributed by Hydrosolve, Inc. This software is commercially available and is used widely by hydrologists to perform analyses of aquifer pumping and slug tests. The software was delivered in a single diskette which contained the executable programs and documentation. The following is a description of software installation testing and validation in accordance with the requirements in table 1 of TOP-18 for commercially acquired software that is not to be modified.

7-8-02

3.2 Hardware

AQTESOLV, Version 2.12–Professional can be run from any PC running Windows 3.x or higher or Windows 95, 98, or NT. No processor speed or memory requirements were specified on the installation instructions provided.

4.0 Prerequisites: none

5.0 Assumptions and Constraints: none

6.0 Test Cases

The following tests should be easily repeatable by any qualified hydrologist using only the information provided below and the attached figures. To ensure that the software performs as advertized, three different validation tests were performed.

6.1 Test Case 1: Theis (1935) confined aquifer solution

The software was used to fit a Theis analytical solution for a confined aquifer to a data set representing an xy plot of the exponential-integral function (also known as the "well function" in hydrology circles). The software prompted me for inputs of well radius, aquifer thickness, and pumping rate: values of 1.0 were assigned to each. Expected output for this problem is an aquifer transmissivity estimate of $1/4\pi$ (0.07958) and a storage coefficient estimate of $1/\pi$ (0.3183). As shown in figure 1, the output is as expected for transmissivity and accurate to three significant figures for the storage coefficient.

6.2 Test Case 2: Neuman (1975) unconfined aquifer solution

A Neuman analytical solution for unconfined aquifers was used to fit the same exponential-integral function. The expected output depends on values chosen for parameters β and Sy, however if these values are very close to zero, the output should be the same as for the Theis solution described above. Values of $1x10^{-10}$ were assigned to both β and Sy. As shown in figure 2, the output is as expected. Although, the type curve generated with these input values is essentially the same as the Theis curve evaluated in the previous paragraph, the values of β and Sy used, although very low, were non-zero. Thus, although a wide range of Neuman type curve solutions is not tested, the mathematical implementation in the software algorithm appears to work correctly and provide accurate estimates of aquifer hydrologic properties.

6.3 Test Case 3: Moench (1984) dual-porosity aquifer solution

A Moench analytical solution for fractured rock aquifers was tested. As there were no convenient data sets available with known outcomes, the original publication of Moench (1984) was used for a qualitative comparison. In that publication, Moench fits his solution to a data set and obtains aquifer parameters. For this test, the parameters obtained by Moench were input into AQTESOLV and the resulting plot was qualitatively compared to the data set and model fit presented by Moench. Figure 3 shows the AQTESOLV output along with two plots from the Moench (1984) publication (taped to page). Visually, the output plot from AQTESOLVE is indistinguishable from the plot given by Moench.

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7.0 Conclusion

The AQTESOLV Version 2.12–Professional aquifer test analysis software provides accurate estimates of aquifer parameters for the cases tested. AQTESOLV software a few other capabilities, such as analysis of slug tests, that were not tested in this validation plan because we do not intend to use these applications for CNWRA work.

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