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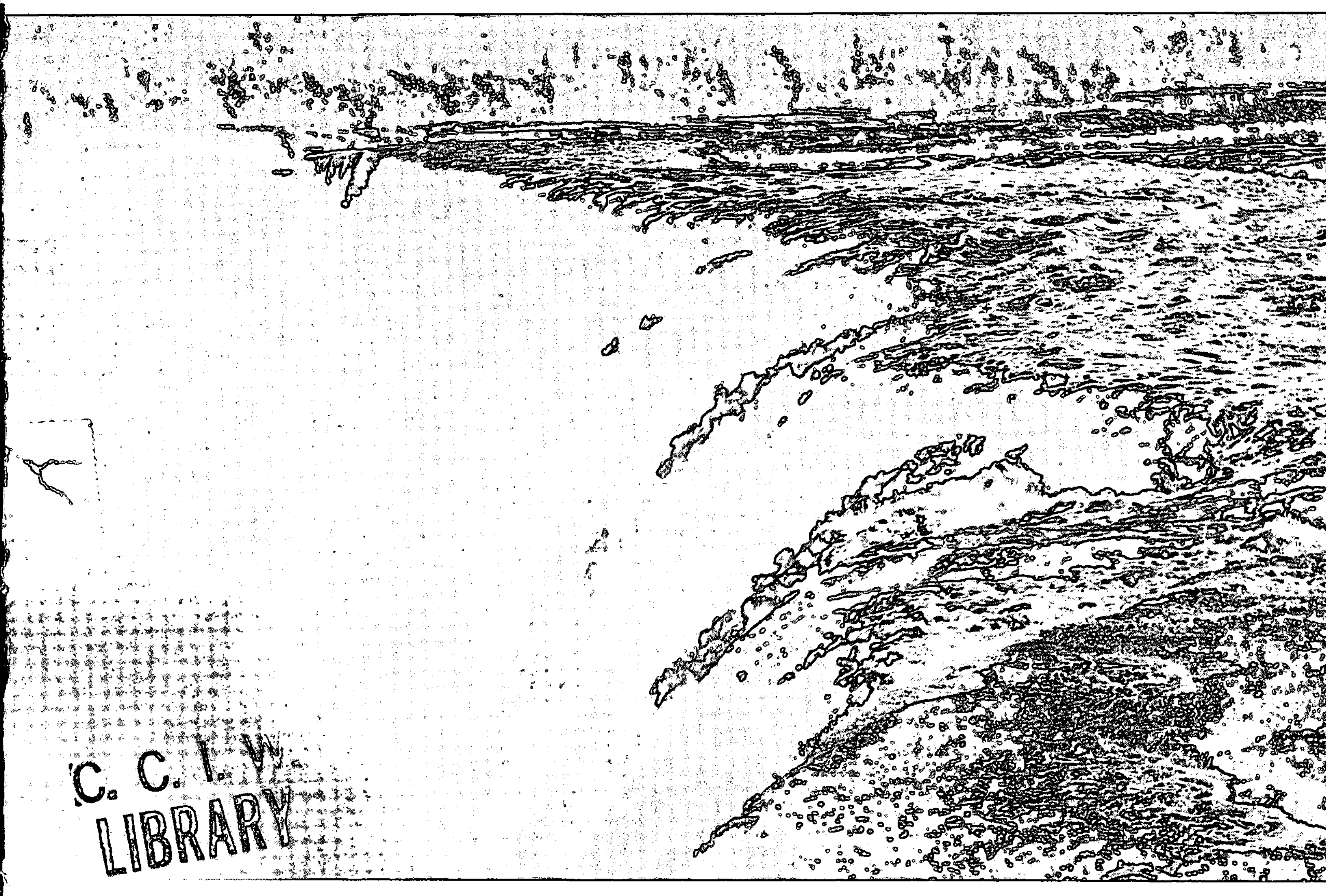

TECHNICAL BULLETIN NO. 149

INLAND WATERS/LANDS DIRECTORATE
ONTARIO REGION
WATER QUALITY BRANCH
BURLINGTON, ONTARIO, 1987

(Disponible en français sur demande)

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Published by authority of
the Minister of the Environment

Cat. No. En 36-503/149E

ISBN 0-662-15594-7

Contents

Illustrations

Abstract

AWQUALABS is a computer-based data capture/management system used for the real-time capture, preprocessing and analysis of raw data and for the organization, management, storage and reporting of results of a series of multi-parameter chemical and physical analyses in a medium-sized water chemistry analytical laboratory.

The system provides facilities. for entering sample identification information, analytical results (both manually and from automated on-line instruments), operational quantities (test costs, time) and quality control data (seasonal limits etc.). It maintains records for all samples received, allows inspection and flagging of data for rechecking of results and produces work sheets for the analysts while maintaining archives of past analyses and quality control information from specified check sums such as duplicates, spikes, references and blanks.

In addition, magnetic tapes can be produced from the database for exchange with other computers. The system accommodates a Shipboard Data Acquisition System (SDAS) designed to collect, store, report or later transfer sample analysis information collected on board a major research vessel during survey cruises on the Great Lakes.

The system allows samples to be associated with projects, each of which will have different sets of tests to be performed. Data from methods with different sensitivities for the same parameter can be handled by the system, which incorporates a dictionary of test characteristics.

Development of the system was started with a PDP 11/34 followed by a PDP-11/60 computer. Minimal effort was required in the final stages to convert the system to a VAX 11/750 machine.

As a result of developing and implementing the system, a number of identified problems in laboratory operations, notably slow sample turnaround, abundance of manual paper work, and other time-consuming and repetitious procedures have been minimized or eliminated.

Résumé

AWQUALABS est un système informatisé qui sert à la saisie, au prétraitement et à l'analyse en temps réel de données brutes. Il sert aussi à l'organisation, à la gestion, au stockage et à la diffusion des résultats d'une série d'analyses chimiques et physiques multiparamétriques effectuées dans des laboratoires de moyennes dimensions chargés de l'analyse de l'eau.

Ce système comprend des installations qui permettent d'y introduire des informations sur les échantillons, les résultats d'analyses (manuellement et à partir d'instruments automatiques branchés à l'ordinateur). On peut y introduire aussi des données quantitatives comme le coût et la durée des tests et des données servant au contrôle de la qualité, notamment les limites saisonnières. Il tient un registre de tous les échantillons reçus, permet d'inspecter et de signaler les données pour la revérification des résultats et produit des feuilles de travail à l'intention des analystes. Il permet aussi d'archiver les résultats des analyses antérieures et les données sur le contrôle de la qualité tirées de résultats témoins obtenus notamment par des tests répétés, des échantillons enrichis, des références et des blancs.

En outre, l'information contenue dans la base de données peut être reproduite sur bande magnétique pour être transmise à d'autres systèmes. AWQUALABS peut être branché à un système embarqué d'acquisition de données (SDAS) servant à la saisie, au stockage, à la diffusion ou au transfert ultérieur de résultats d'analyse d'échantillons obtenus à bord de gros navires de recherche au cours de missions sur les Grands lacs.

Les échantillons peuvent être reliés à divers travaux impliquant chacun différentes batteries de tests. Le système, qui comprend un dictionnaire des caractéristiques des tests, peut aussi traiter les données obtenues par des méthodes exigeant différents degrés de précision pour l'étude d'un même paramètre.

Initialement, le système consistait en un PDP 11/34, puis en un PDP 11/60. Par la suite, il a été facile d'opter pour un ordinateur VAX 11/750.

L'utilisation d'AWQUALABS a permis de réduire au minimum ou d'éliminer un certain nombre de problèmes reliés aux travaux de laboratoire, comme la lenteur du traitement des échantillons, la paperasserie et d'autres tâches répétitives qui nécessitaient beaucoup de temps.

An Automated Computer-Based Water Quality Analytical Laboratory Data Capture/Management System (AWQUALABS)

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INTRODUCTION

AWQUALABS is a computer-based Automated Water Quality Analytical Laboratory System designed to perform two major functions in the operations of the Water Quality Branch analytical chemistry laboratories of Environment Canada. These functions are

(i) the real-time capture, preprocessing, and analysis of raw data from a variety of analytical instruments at a corresponding data throughput level and

(ii) the organization, management, storage and reporting of results of a series of multi-parameter chemical and physical analyses.

The system was initially designed to process up to about 25 000 samples undergoing a total of some 375 000 tests annually. It will accept information from a variety of on-line instruments with analog or teletype-like outputs, computer-based equipment, multifunction computer terminals or from manual input sources. The instruments initially physically connected to the CPU (central processing unit) included five Perkin-Elmer atomic absorption spectrophotometers, 18 Technicon AutoAnalyzers®, several gas chromatographs via two Spectra Physics SP 4000 central processors, two Hewlett-Packard model 185B CHN analyzers, a UV-Vis spectrophotometer, and an ARL computerized inductively coupled argon plasma spectrometer system (ICAP). During the course of system development, however, there was a major reorganization of the laboratory which resulted in changes in operational needs and, hence, the functional requirements of the perceived system. For example, some 75 000 samples for a total of 1 125 000 tests are now being processed in AWQUALABS per year.

The data capture aspects entail, among other things, (i) sampling and processing analog and/or digital signals and signal conversion as necessary, (ii) calculation of standards data and plotting of standard reference curves, (iii) computation and reporting of standards and samples data and results for prescribed parameters, (iv) storage and retrieval of standards data, (v) creation of transaction files for bigger systems such as Environment Canada's National Water Quality Data Bank (NAQUADAT) and the Storage and Retrieval (STAR) system at the Canada Centre for Inland Waters (CCIW), (vi) communication linkage to remote users, and (vii) processing of incoming sample information and analytical data.

The data management functions include awareness functions, generation of sample reports, sample or project status reports, monthly summary and related laboratory statistical reports, quality control checks and flagging of data as necessary, calculation of resources used for projects, and calculation of indices for the laboratory operational performance measurement system (OPMS).

Briefly, therefore, the system is designed to perform functions such as carrying out real-time, on-line processing of a continuous flow of captured data from automated and manual input sources while maintaining an ongoing dialogue with (i) users in the sample logging area, (ii) analysts involved in sample analysis, and (iii) laboratory supervisors and managers interested in quality assurance and management information.

The salient technical and design aspects of AWQUALABS are detailed in Inland Waters/Lands Directorate Technical Bulletin No. 150 (Beal *et al*., 1987). The system was initially developed around a PDP 11/34 computer upgraded by add-ons and including an RSX-11M operating system and RMS-11K. The PDP 11/34 computer was later replaced by a PDP 11/60 machine with which system program development continued using RSX-11M, Basic plus 2 and RMS-11K. Ongoing evaluation of the AWQUALABS, along with bench-marking exercises on a VAX 11/750 system (courtesy of Digital Equipment Corporation), led to the replacement of the PDP 11/60 computer with a VAX 11/750 machine in March 1983.

AWQUALABS used the LABS 11 system as a base, which had been produced by the Water Quality Branch of the Inland Waters Directorate (IWD), Atlantic Region, Environment Canada (1978). The original LABS 11 programs ran under the RT-11 version 2B operating system using Multiuser Basic. LABS 11 was designed to supply data to NAQUADAT, and this compatibility has been maintained in the AWQUALABS system. Compatibility was also extended to include the STAR system in use at Canada Centre for Inland Waters, Burlington. Furthermore, samples not intended for STAR or NAQUADAT can be easily processed.

The benefits accrued from the use of this system include (i) more efficient and effective acquisition, reduction, reporting and accessibility of data generated in the laboratory, (ii) improved and more comprehensive laboratory quality assurance practices, (iii) increased sample throughput and, hence, better productivity, (iv) minimization or elimination of repetitious error-prone and tedious manual sample and data processing procedures, and (v) more timely report generation and overall improvement in laboratory operations and laboratory management procedures. For example, a 30% improvement in throughput was realized with the Perkin-Elmer 403 atomic absorption instrument with a reduction in time for data capture functions from 7.5 to 5.25 h. Before the software interfacing of the ARL ICAP was completed, the output from one day of normal laboratory operation required 6 to 7 h of the analyst's time for manual data entry into AWQUALABS. This task can now be done in about 5 min, thereby essentially doubling the capacity of the ICAP facility. Also, a saving of close to 100% was realized in the keypunching of data with the elimination of this function. An added benefit has been the improved integrity of the transferred data with the attendant reduction in time required for checking of the data.

INFORMATION FLOW

Schematics of Information Flow for three typical processes, as presented in the Functional Specifications document of the AWQUALABS development project, are shown in Figures 1A–C. This is the way it used to be. Figures 2A–C show the same schematics depicting the situation following implementation of AWQUALABS.

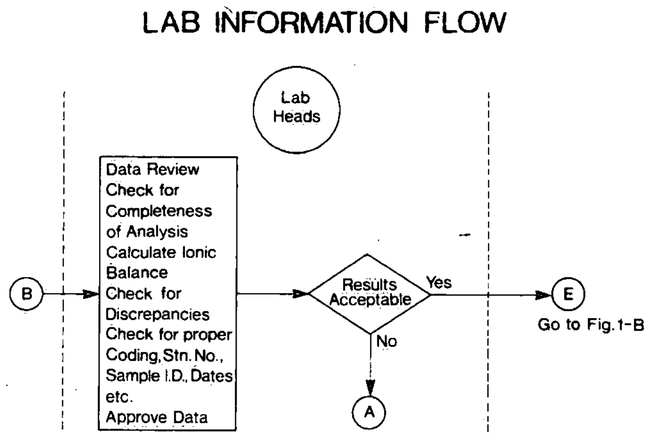

Figure 1-A. Sample processing-acceptance: Pre-AWQUALABS.

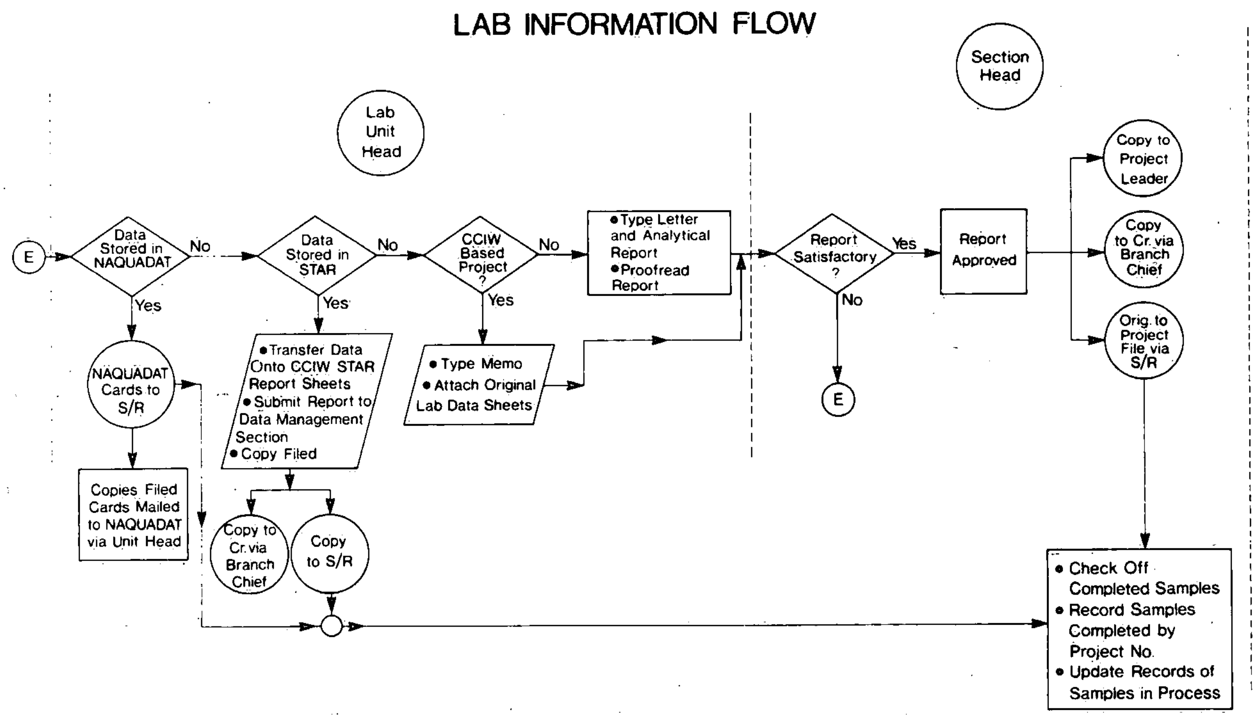

Figure 1-B. Sample processing-acceptance: Pre-AWQUALABS.

LAB INFORMATION FLOW

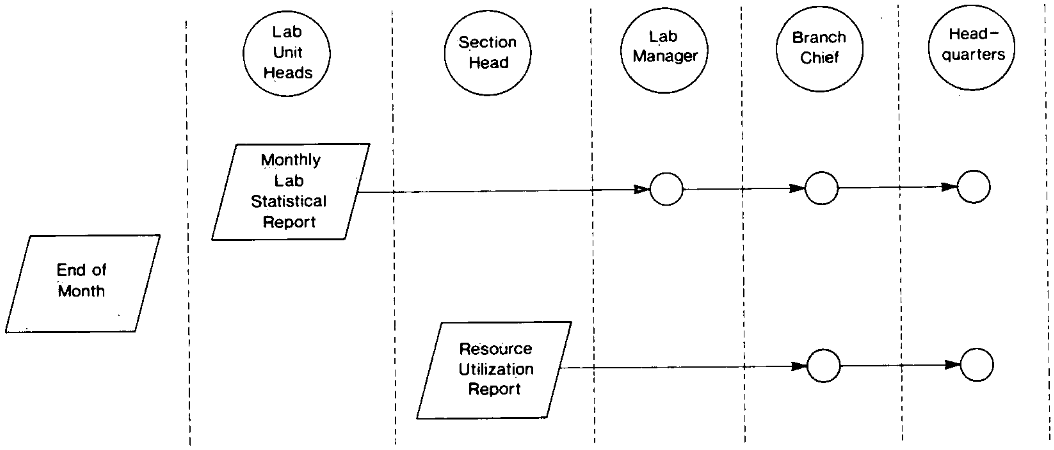

Figure 1-C. Monthly statistical reporting: Pre-AWQUALABS.

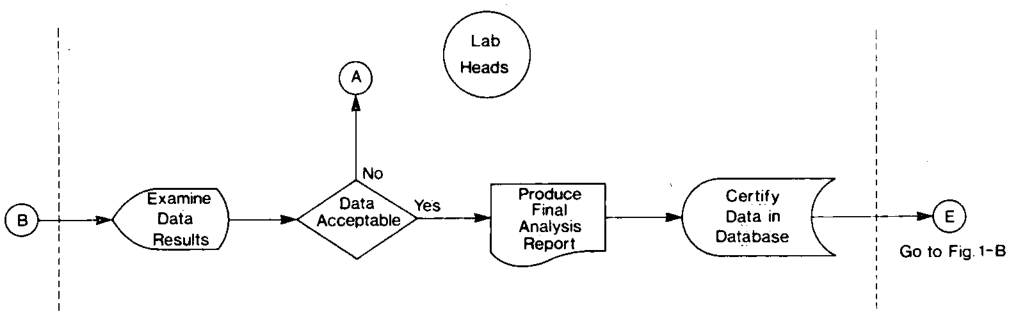

Figure 2-A. Sample processing-acceptance: AWQUALABS.

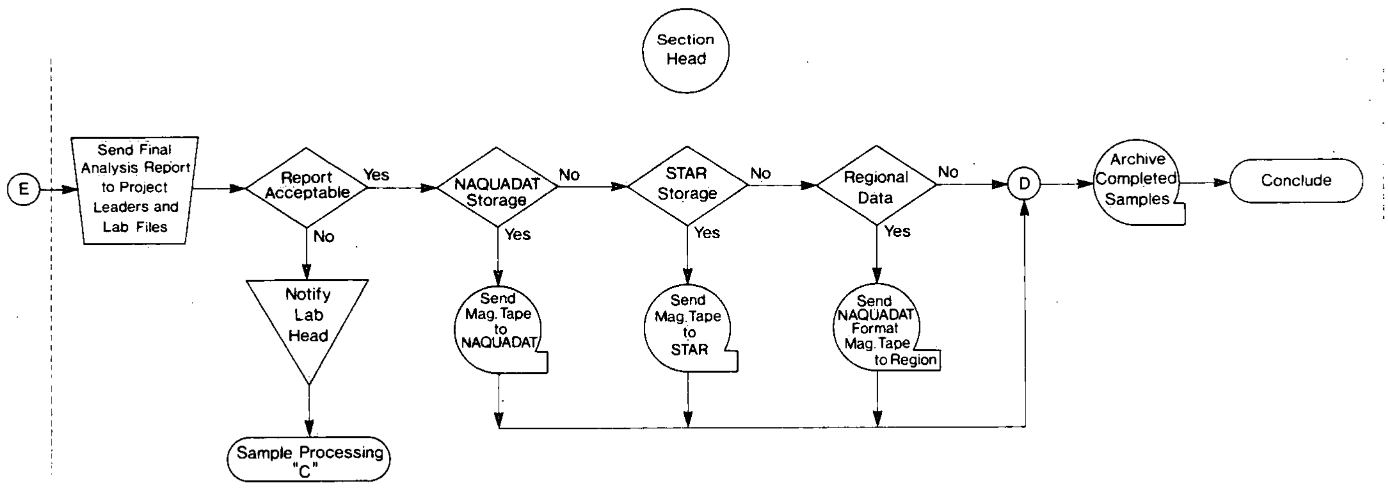

Figure 2-B. Sample processing-acceptance: AWQUALABS.

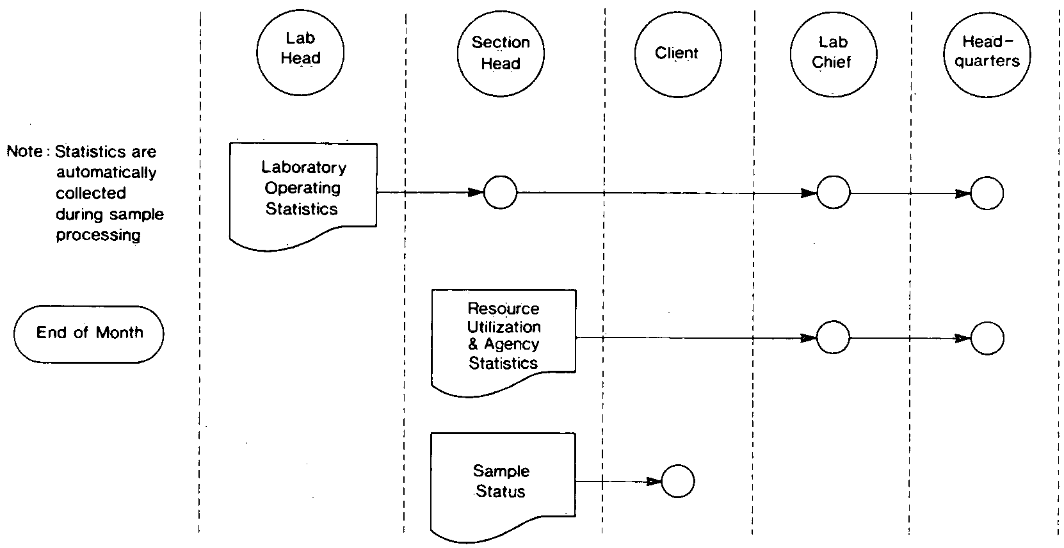

Figure 2–C. Sample processing-acceptance: AWQUALABS.

There are three basic designs: Initiation of Project, Sample Processing, and Report Processing. There have been no major changes in the information flow with the installation of AWQUALABS. All decisions are still initiated by lab personnel, but once information has been introduced to the system, it becomes part of the automated process. There is no further need for any manual data manipulation or abundant paper shuffling. The process involving all calibrations and data and status reports generation are now automated. The only major process not yet fully automated is the Laboratory Quality Control.

SYSTEM DATA ORGANIZATION

The database files of the AWQUALABS system can be separated into four logical divisions: Samples, Support, Statistics, and Miscellaneous. The Samples division contains sample identifications, analytical results for each sample, and an optional sample description. The Support division contains all pre-sample entry information such as an archive of project/study identification, parameter schemas to be used for the samples, a dictionary of parameters, a list of valid NAQUADAT stations, and a list of descriptive codes. The Statistics division contains monthly totals for each project of numbers of samples submitted, analyses expected or completed, and samples completed. There are also monthly totals for each parameter of the number of various aliquot types analyzed. The Miscellaneous division contains those files that belong to individual users or that are accessed by only one program.

Samples

Analytical values are grouped according to the Sample identifier of the container from which the material was taken. Several containers may contain aliquots of the same sample, each labelled by the same identifier. This is also called the Lab Number.

Samples are collected in groups by project/study. The project/study number identifies the person, division, region and agency which requested the analysis and supplied the sampled material. A schema, which is an arrangement of methods that could be used for analysis of a sample, has to be denoted. The methods are grouped by parameter. Every project/study has its own list of schemas. Each such schema is identified by a letter. The letter is attached to the appropriate method entries in the database. Only previously designated schemas can be assigned to a sample of a project for analysis.

Each parameter to be measured for a sample is distinguished by one or more analytical methods from the dictionary. Only one value per parameter can be approved. For example, the parameter "Aluminum Filtered" can be analyzed by direct aspiration (NAQUADAT analysis code 13102) or by solvent extraction (NAQUADAT analysis code 13106). Space for results from both methods would be included in the database for the sample. Method 13102 is analyzed first, and then the value is examined by the analyst who may decide that there is insufficient resolution. Method 13106 is then tried. Only the value for the last employed method would be used in reports, although values for both methods are present in the database.

Every method is described in the following way:

(1) Identification code (NAQUADAT, STAR or AWQUALABS)
(2) Parameter name
(3) Qualifiers
(4) Method name
(5) Instrument type
(6) Group name
(7) Reporting units.

There are three types of sample results, based upon the eventual destination of the analysis results:

(1) NAQUADAT sample results are intended to be stored in the NAQUADAT system in Ottawa, in one of the similarly organized databases at CCIW, or to be sent to the various regional labs.

(2) SURVEILLANCE sample results are intended to be stored in the STAR Data Bank, or in one of the similarly organized databases at CCIW.

(3) Other sample results are sent only to the leader of the project/study.

Each of these different types requires different information for each sample.

Sample Description Information

The following descriptions indicate what information is available for samples of the three different types.

NAQUADAT: The analytical results from these samples are stored in the NAQUADAT Data Bank in Ottawa along with the following typical information:

(1) Project identifier
(2) Station
(3) Submitter identifier
(4) Date sampled
(5) Time sampled
(6) Time zone
(7) Field identifier
(8) Number of containers
(9) Substrate
(10) Composite lab number
(11) Turnaround time
(12) Description
(13) Schema of parameters
(14) Analysis code.

SURVEILLANCE: The analytical results from these samples are stored in the STAR Data Bank at CCIW with the following typical information:

(1) Project identifier
(2) Cruise number
(3) Monitor station number
(4) Consecutive station number
(5) Depth
(6) Number of containers
(7) Substrate
(8) Composite lab number
(9) Turnaround time
(10) Schema of parameters.

OTHER: The analytical results from these samples are sent to the leader of the project/study with the following typical information:

(1) Project identifier
(2) Date sampled
(3) Field identifier
(4) Number of containers
(5) Substrate
(6) Composite lab number
(7) Turnaround time
(8) Schema of parameters.

Data submission is effected in one of three ways as follows:

ON LINE: Some of the instruments can be connected directly to the computer, sending their results to an electronic port.

MANUAL: Where the recording instrument does not connect directly to the computer, results can be typed in by means of a typewriter terminal.

SHIPBOARD: Analytical results for a few parameters, collected by automated shipboard analyses of the samples, are stored on cassette tape. This tape is hooked up to the AWQUALABS computer for direct sample initialization and data submission at the end of each survey.

SYSTEM PROGRAM ORGANIZATION

The AWQUALABS programs can be loosely organized into seven types: sample entry, sample management, sample analysis, acceptance of sample analysis results, sample completion, laboratory management, and database management.

Figure 3 shows a schematic of AWQUALABS. The programs are written in Basic + 2 language for the VAX 11/750 computer with VMS. The programs are designed to (i) accept instructions from CRT terminals; (ii) accept data from CRT terminals, instruments, tapes or other computers; (iii) produce reports on CRT terminals or line printer; (iv) send analytical results to other databases; (v) maintain a tape archive of analytical results; and (vi) maintain a database on on-line disk storage.

Figure 4 shows the processes relating to the sample entry function. Information about samples that have been received is typed in daily. This process reserves space within the sample database for the analytical results.

The primary sample entry programs (NAQRE, MINRE, SURRE) accept information typed by the entry clerk and store the instructions in a temporary file which is emptied overnight by another program (REDAT) to initialize the samples. The remaining two programs (SDAS and MINLA) initialize the samples directly, one from the file of the shipboard analysis data (SDAS) and the other from the information typed by the clerk. The temporary file and program REDAT method was introduced on the PDP 11/60 because of slow response during peak user hours (40 samples per day initialized when 400 were received). Now there is overnight turnaround for all sample initializations.

Report COM is used by the entry clerk to determine whether samples have been initialized properly. If not, then there is a set of programs that can be used to make corrections to the information (MDESC, MLABN, MNAQ, MPADD, MPARM, MSTAT). Statistics for the number of samples received and time required to do analyses are updated automatically as the samples are logged in.

The sample management processes are shown in Figure 5. The analyst examines the sample database to determine which samples are awaiting specific analyses. It is also necessary to do quality control checks on the validity of the analytical results already submitted.

The choice of an analysis to be done must be followed by selection of the samples which are waiting for this particular analysis (WORK, SELWK). Preliminary results can be viewed on the screen (PRE, PRE4). These reports, as shown in Figure 6, are of the same format as the Final Sample Analysis Reports. Since some parameter values bear a relationship with the results of other parameters, there are Quality Control programs (QCCL, IBAL, IBALPR, IBALMN, IBALCA) to accommodate this aspect. The sample analysis scheme is shown in Figure 7.

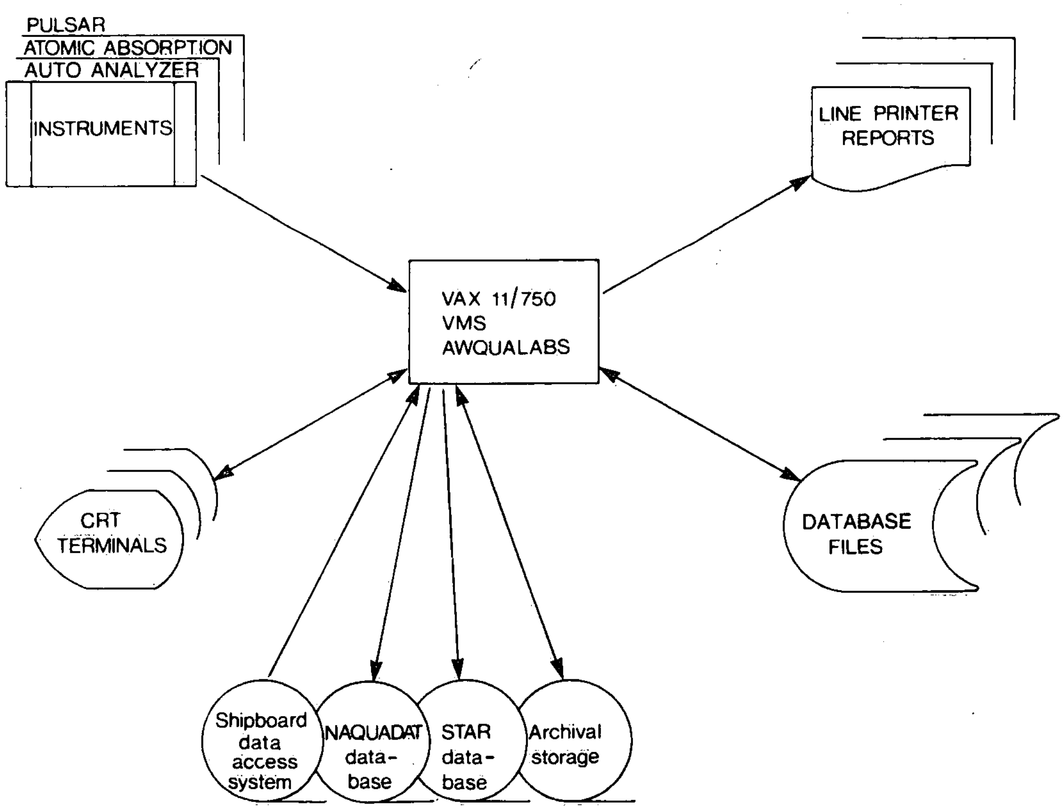

Figure 3. System organization.

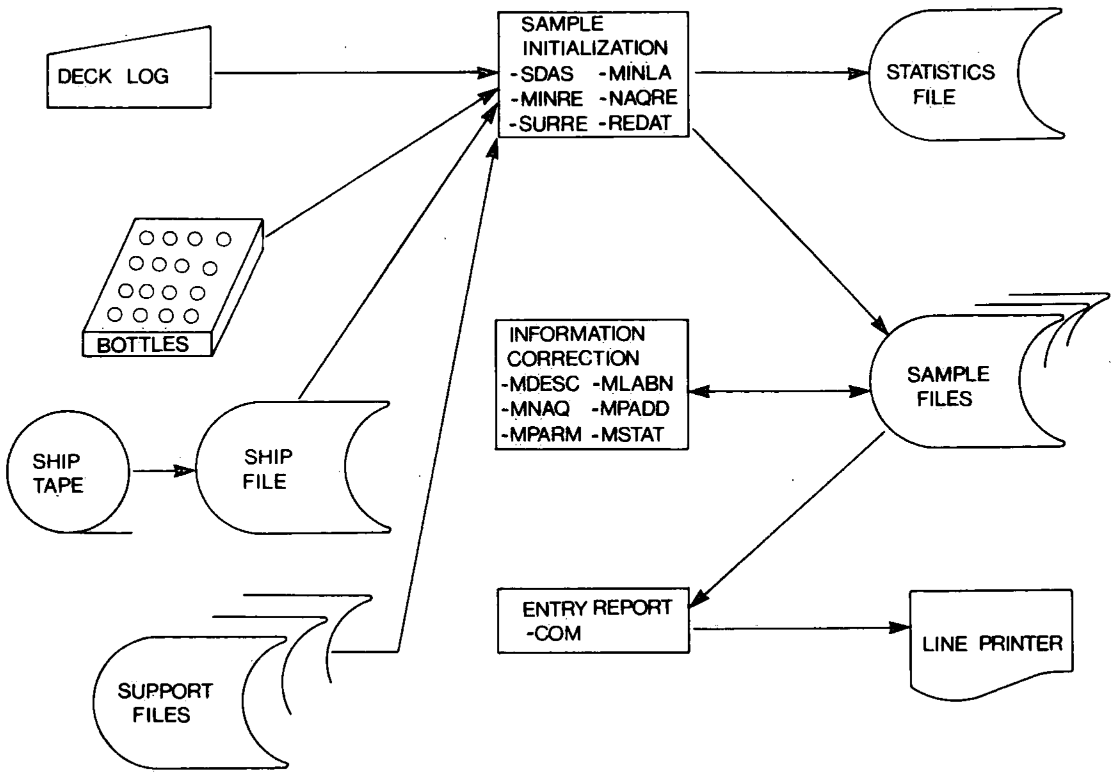

Figure 4. Sample entry (daily).

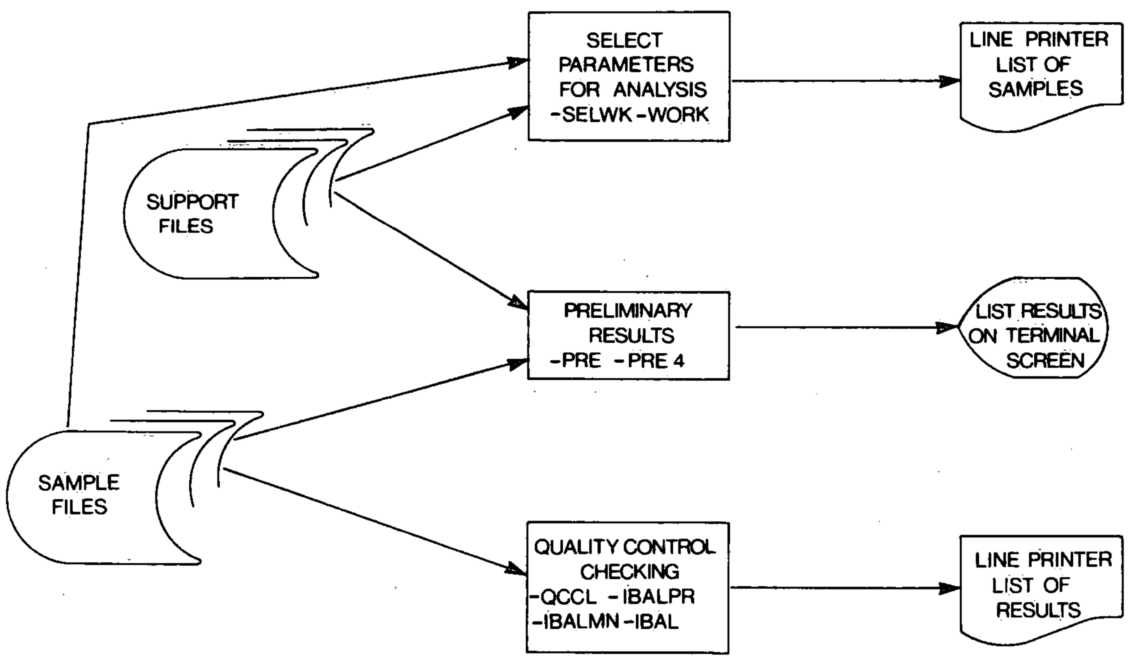

Figure 5. Sample management.

WATER QUALITY LAB

27-Aug-84 PRELIMINARY SAMPLE ANALYSIS REPORT

STUDY ID: 401-84

STUDY TITLE: PACIFIC REGION WATER QUALITY

STUDY LEADER: F.MAH

Sample	8408951	8408952	8408953
Date last analyzed	15-Aug-84	22-Aug-84	15-Aug-84
No. containers	2	3	2
Date received	01-Aug-84	01-Aug-84	01-Aug-84
Exp.completion	26-Sep-84	26-Sep-84	26-Sep-84
CD-TOT(MG/L)	<.001 ?	<.001 ?	<.001 ?
CU-TOT(MG/L)	.008 ?	.004 ?	.004 ?
FE-TOT(MG/L)	3.45 ?	.44 ?	.027 ?1
PB-TOT(MG/L)	.004 ?	.007 ?	.002 ?
MN-TOT(MG/L)	.08 ?	.01 ?	<.01 ?
ZN-TOT(MG/L)	<.001 ?	.003 ?	.004 ?
AS-TOT(MG/L)			
SE-TOT(MG/L)			
HG-TOT(MUG/L)	/////////	<0.02 ?	/////////

Figure 6. Printout of preliminary sample analysis report.

The analyst runs the instruments, either placing the results directly in the computer or typing the values individually. The submission of analytical results begins with a decision on the use of a tray pattern. A tray pattern file is a user file which identifies the samples in the order in which they will be examined by the instrument. When the instrument measures the amount to be recorded in the sample database, without further calculations required, the values can be typed into the computer manually and program ENMET will place them in the sample database. Otherwise, a tray pattern file is used to reduce the amount of human interaction with the values.

If the instrument is not directly connected to the computer, then the analyst types the instrument responses into the tray pattern. If the instrument is directly connected to the computer, then one of the instrument packages can be used to collect the instrument responses (CHLOR, AUTON, ATABS, PULSAR). As soon as the instrument responses have been placed in the tray pattern file, one of the analytical packages can be used, i.e., Least Square Fit of the Standards (TYFIT, THILO), Chlorophyll (TYCHL, CHSUB), Sulphate (TYSUL), change volume related results to weight related results (TYWET) or specify the number of decimal places in the final results (TYDEC). The final results are copied from the tray pattern file to the sample database (TYCIP).

Through the "Acceptance of Sample Analysis Results" process, which is shown schematically in Figure 8, samples that have been completed are determined and marked for transfer to NAQUADAT or STAR. The detection of completed samples is done by means of a program (COMP) which lists only those samples that have received a value for every expected parameter. The parameter values must be checked and marked "OK" (MINCOL, MINFN, NAQFN, SURFN, ACCEP) by the Final Sample Analysis Reports. A copy of this report is sent to the contact person of the project for which the sample was analyzed.

The processes involved in the sample completion function are shown in Figure 9. The programs transfer results to NAQUADAT or STAR, as requested, and then archive the accepted data.

The results of accepted samples are ready now for transmission and archiving. All samples of projects intended for a NAQUADAT style database are sent to tape (NAQTR) in the format required for input to such a database. The surveillance sample results are intended for the STAR database. They are sent to tape (STAR) in the required format. All samples that reach this point are then archived (ARCIV) by copying to file and tape. Then the samples are deleted from the database.

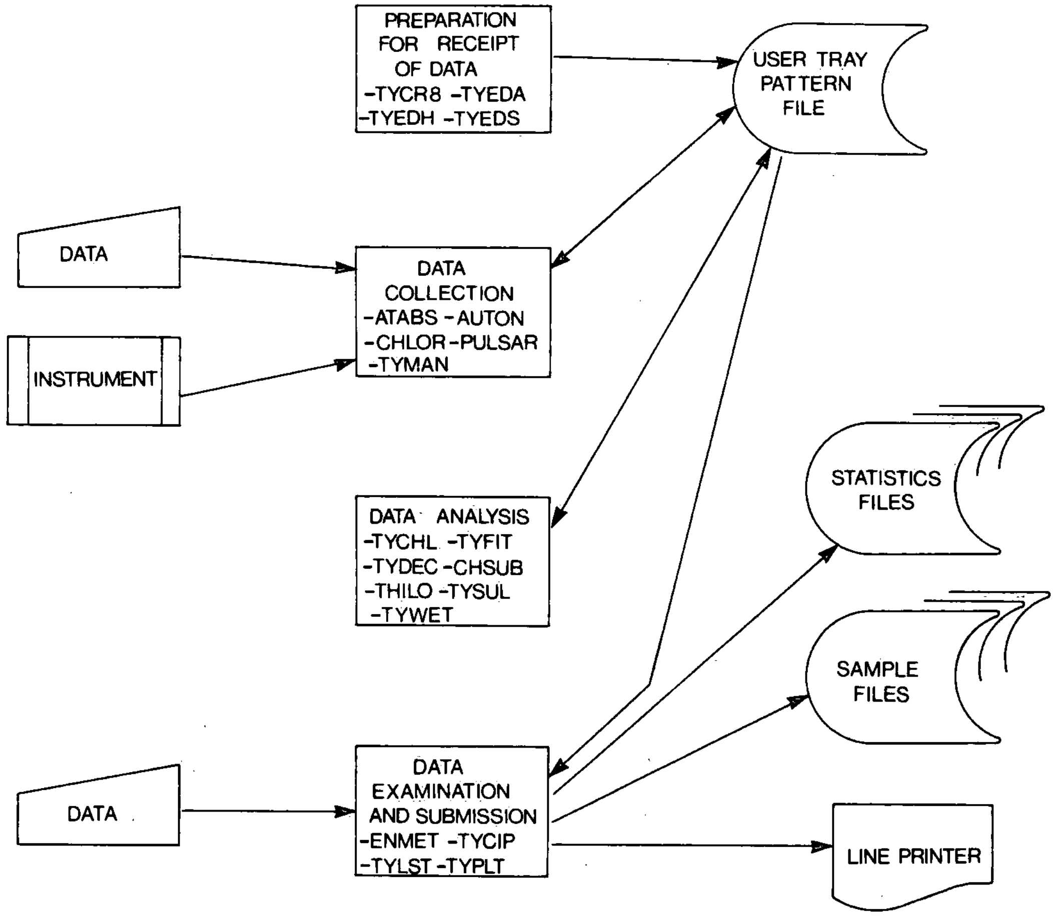

Figure 7. Sample analysis.

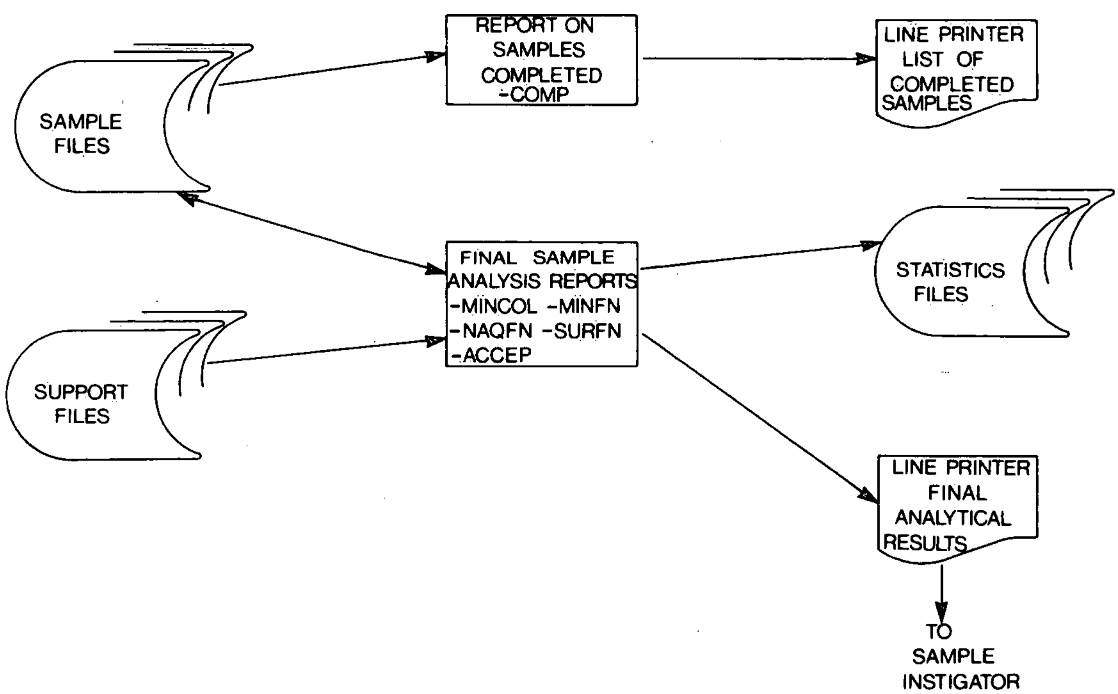

Figure 8. Acceptance of sample analysis results.

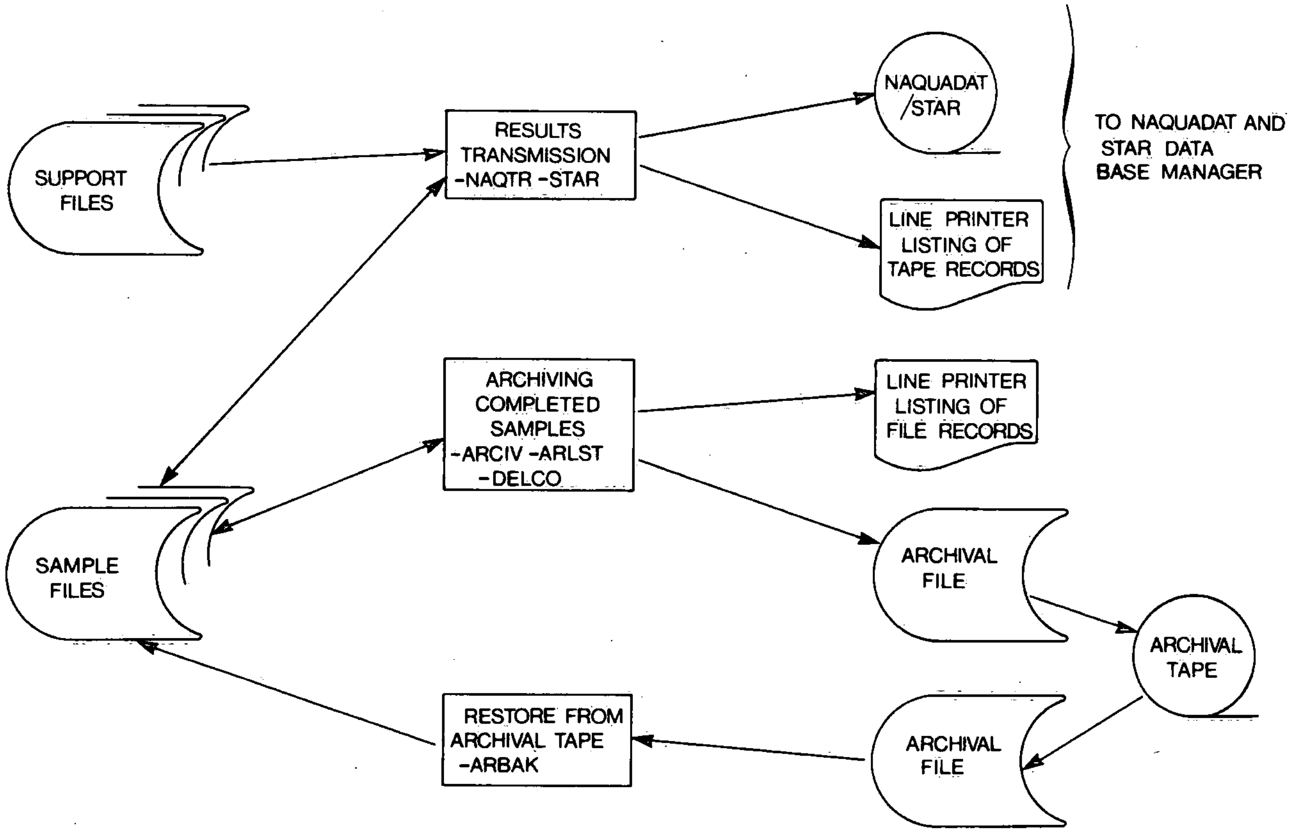

Figure 9. Sample completion.

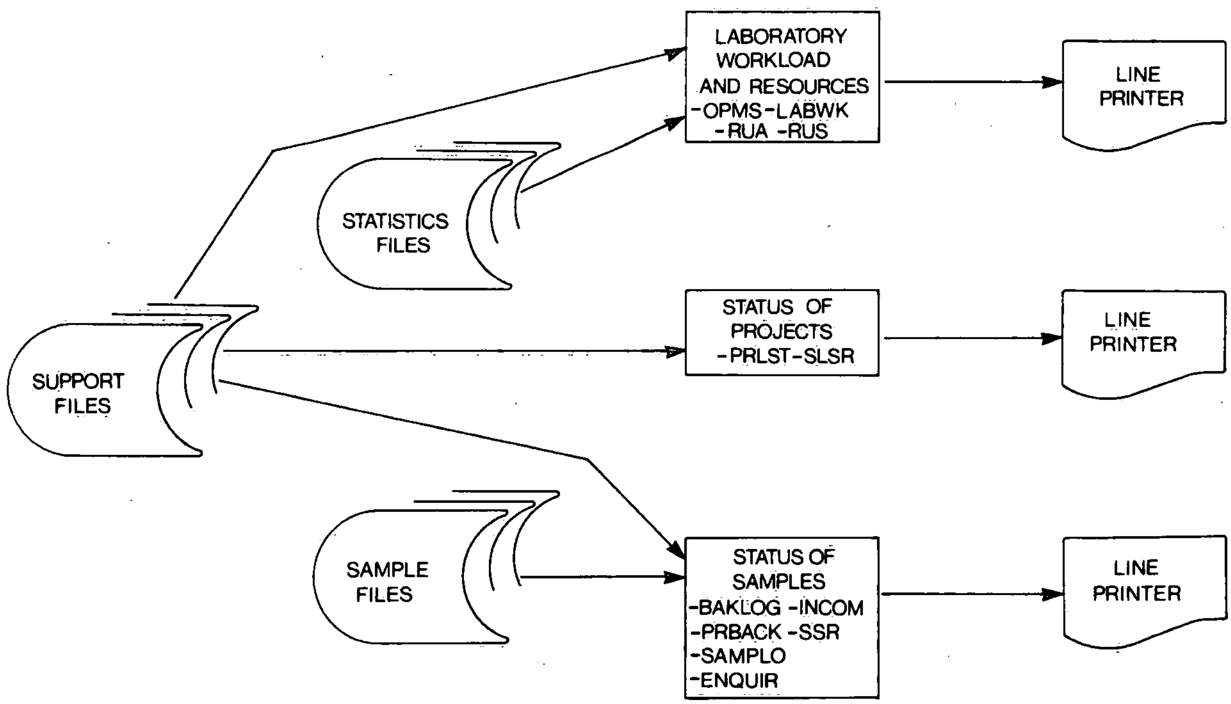

Figure 10. Laboratory management.

As shown in Figure 10, the laboratory management function entails the generation of reports on laboratory workload, resource usage, and sample or project status. The heads of the different laboratory sections require various statistics by which they can control the work to be done and determine the efficiency of the laboratory operation.

```
(30-Aug-84)                          LABORATORY WORKLOAD

LABORATORY UNIT: ALL                                   FISCAL YEAR:  84 / 85

SAMPLES OF FISCAL 84 / 85                    THIS MONTH          TOTAL
        RECEIVED                                3002             12235
        COMPLETED                               1350             2580
        IN PROCESS                              9655

TEST COMPLETED                               THIS MONTH          FISCAL YEAR
        SAMPLES                                 15179            64974
        STANDARDS                               2778             10463
        BLANKS                                  692              3147
        DUPLICATES                              507              1740
        SPIKES                                  291              1463
        DILUTIONS                               1290             3389
        REFERENCES                              688              2452
        WASHES                                  1220             3893
        RECHECKS                                1523             3168
        TOTAL                                   24168            94689
```

METHOD ID	NAME	SMPLS.	STDS.	BLKS.	DUPS.	SPKS.	DILNS.
A039	SI02_REA-UNF-_AU	102	6	13	6	1	0
A040	S04_FLT-_AU	121	328	72	15	2	251
A041	S04_UNF-_AU	143	37	28	7	1	4
A048	C_INO-FLT-_AU	484	186	46	36	0	1
A049	C_ORG-FLT-_AU	0	0	0	0	0	0
A053	N_KJ-UNF-_AU	417	48	24	26	9	41
A054	N_KJ-FLT-_AU	715	100	43	35	16	105
A057	N_N+N-FLT-_AU	251	7	20	14	3	15
A058	N_N+N-UNF-_AU	245	11	29	17	4	20
A062	N_NH3-FLT-_AU	5	1	4	1	1	42
A063	N_NH3-UNF-_AU	261	24	0	0	16	79
A066	N_T-PAR-_CHN	38	0	0	0	0	0
A067	N_T-PAR-I-_CHN	4	0	0	0	0	0
A069	P_REA-FLT-_AU	406	0	0	0	0	0
A073	P_T-UNF-_AU	99	7	9	0	0	1
A074	P_T-FLT-_AU	1801	104	107	0	0	25
A077	AL_FLT-_AA	7	6	0	0	0	0
A079	AL_FLT-_AA	23	16	0	0	2	0
A080	AL_EXT-UNF-_AA	97	26	0	3	0	0
A082	AL_EXT-UNF-_AA	31	30	0	2	2	0
A087	BA_FLT-_AA	44	7	0	0	2	0
A088	BA_EXT-UNF-_AA	236	45	0	4	9	0
A098	CD_T-UNF-_AA	171	29	0	0	6	0

Figure 11. Printout of laboratory workload report.

It is possible to get reports of the workload conditions under which the labs have operated (LABWK, OPMS) and also to identify the projects and studies for which the lab resources were used and to what percentage (Figs. 11 and 12). A great deal of information about the various projects is archived at the beginning of each fiscal year. This information can be listed as it is required (PRLST, SLRS). An example of a PRLST printout is shown in Figure 13.

An important component of laboratory management is the knowledge of which parameters are holding back the acceptance of samples. There are several reports available with information about the backlog (INCOM, PRBACK, SSR, BAKLOG, SAMFLO, ENQUIR). Two such typical reports are shown in Figures 14 and 15.

Database Management

The database maintenance programs permit the making of corrections to the database files when necessary (Fig. 16). There are a number of programs necessary to deal with errors that may have crept into the various databases. For example, invalid samples must be removed. If the system goes down or the user aborts the program during an update, the parameter linkages may be invalid. As shown in Figure 16, several programs were written to handle problems that have occurred in the past. There is also a set of programs to update the support files, for example, to add a new parameter, a new schema, a new project, or a new NAQUADAT station.

```
                 OPMS - OPERATIONAL PERFORMANCE MEASUREMENT SYSTEM
30-Aug-84
                      FISCAL YEAR:  84 / 85       MONTH: AUG

MONTH
-----

SAMPLE TESTS                            15179

ALL TESTS                               24168

SPIKES                                  291

REPLICATES                              507

RECHECKS                                1523

STANDARDS                               2778

BLANKS                                  692

MAN-HOURS USED                          2258.56

MANPOWER EFFICIENCY                     .673655

PERCENT QUALITY CONTROL                 12.7584

PERCENT STANDARDIZATION                 19.0743

SAMPLES RECEIVED THIS FISCAL YEAR       9139

SAMPLES PROCESSED THIS FISCAL YEAR      7480

PERCENT LAB EFFECTIVENESS               81.847
```

Figure 12. Printout of operational performance measurement report.

```
----------401-84----------
.Title.                                      PACIFIC REGION
                                             WATER QUALITY
.Type project/study.      WQB-PR
.Leader.                  F.MAH
.Address.                 WQB,VANCOUVER
.Telephone.               987-7756
.Full desc file spec.
.Division.                 1 LABORATORY
.Region.                   5 PACIFIC
.Agency.                   5 IWD-WQB PACIFIC
.Nat/Reg program.         REGIONAL
.Turnaround.               8
.Resp labs (max 3).       OAL, IAL
.Starting date.           APRIL 84
.Completion date.         MARCH 85
.When required.
.Schemas (max 20).        A PAHS, B PAHW, C TCDD-F, D TCDD-S, E PAHPTHF,
                          F PAHPTHW, G PAHPTHS, H TM-FISH8, I HG-FISH,
                          J TM-W6TU, K AS/SE, L HG-TOT, M BA-DISS, N BA-EXT,
                          O MO-TOTU, P CA&MG
.Samp freq.
.No smpls expected.        0
.Smpl types (max 6).                          1 WATER
                                              9 FISH
                                              6 SEDIMENT

.Project/Study id prev yr.999-82
```

		TOTALS	
	SAMPLES RECEIVED	SAMPLES ANALYZED	TESTS
MAY 84	302	0	91
JUN 84	297	0	1738
JUL 84	411	396	2759
AUG 84	185	588	1509
TOT	1195	984	6097

		TOTALS	
	TIME REQUIRED	TIME USED	COST
MAY 84	86.5597	1.82	.728
JUN 84	126.34	134.812	1805.15
JUL 84	176.021	220.981	6297.76
AUG 84	111.62	125.842	3586.43
TOT	500.54	483.454	11690.1

Figure 13. Printout of project information listing.

S A M P L E   F L O W
SAMPLES - 8414110 TO 8414120
- PROJECT: 777-84

09-Oct-84

SAMPLE ID	DAYS REM.	DAYS OVER	DUE DATE	SCHEMAS	PARAM.REM.	PARAM.COMP.	ACCEPTANCE
8414110	50	0	28-NOV-84	A AESRAIN	1	10	
				B RAIN-FLD	0	9	
8414111	50	0	28-NOV-84	A AESRAIN	1	10	
				B RAIN-FLD	0	9	
8414112	50	0	28-NOV-84	A AESRAIN	1	10	
				B RAIN-FLD	0	9	
8414113	50	0	28-NOV-84	A AESRAIN	1	10	
				B RAIN-FLD	0	9	
8414114	50	0	28-NOV-84	A AESRAIN	1	10	
				B RAIN-FLD	0	9	
8414115	50	0	28-NOV-84	A AESRAIN	3	8	
				B RAIN-FLD	0	9	
8414116	50	0	28-NOV-84	A AESRAIN	1	10	
				B RAIN-FLD	0	9	
8414117	50	0	28-NOV-84	A AESRAIN	1	10	
				B RAIN-FLD	0	9	
8414118	50	0	28-NOV-84	A AESRAIN	1	10	
				B RAIN-FLD	0	9	
8414119	50	0	28-NOV-84	A AESRAIN	1	10	
				B RAIN-FLD	0	9	
8414120	50	0	28-NOV-84	A AESRAIN	1	10	
				B RAIN-FLD	0	9	

TOTAL # COMPLETED SAMPLES = 0

TOTAL # UNCOMPLETED SAMPLES = 11

Figure 14. Printout of sample flow report.

```
L A B O R A T O R Y   W O R K   S H E E T

PARAMETER - A463(33008)(S314)AS_T-UNF_ACID.DIG_ICP_TM_MG/L   30-Aug-84
THERE ARE 101 SAMPLES AWAITING ANALYSIS

RANGE REQUESTED: 8408000 - 8409000

 097-84          8408060 - 8408065

 203-84          8408742 - 8408754

 108-84          8408886 - 8408888

 108-84          8408890

 401-84          8408923 - 8409000
```

Figure 15. Printout of laboratory work sheet.

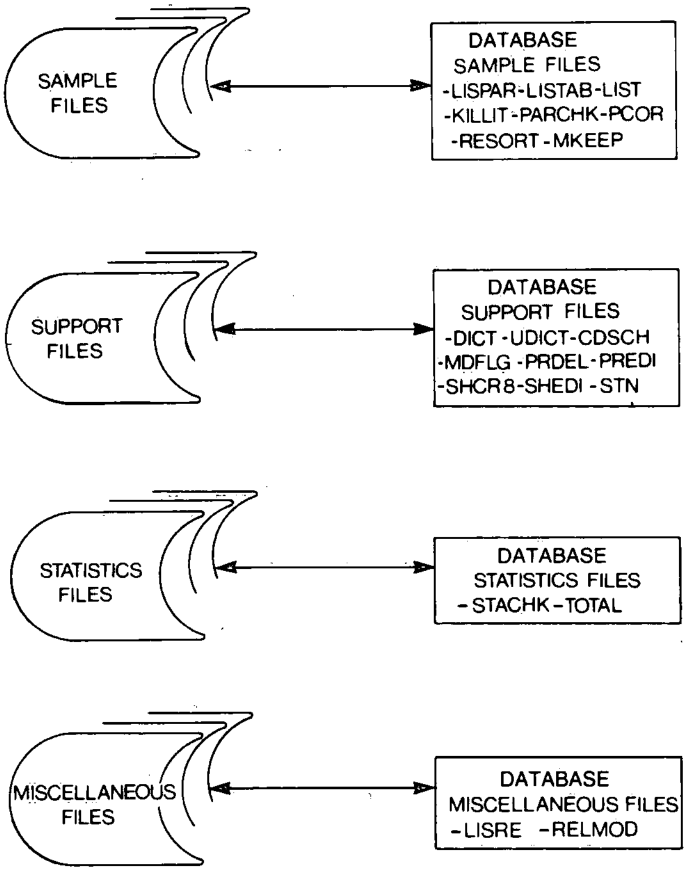

Figure 16. Database maintenance.

CONCLUSION

AWQUALABS represents a successful, although protracted, attempt to design, develop and implement an automated computerized data capture/management system for a modern well-equipped water chemistry analytical laboratory. Every aspect of laboratory operation that was amenable to cost-effective automation has been automated. Based on the users' responses to a recent questionnaire, the system appears to be satisfying their current needs. Also, laboratory operational efficiency and effectiveness have been improved considerably with the implementation of the system.

ACKNOWLEDGMENTS

Although it is impossible to name everyone involved in the planning and development of AWQUALABS, the authors wish to express their appreciation to all who helped in some way. Specifically acknowledged is the contribution made by the following people who, at some time during the project, formed part of the development team:

R. Bingham
P. Brooksbank
H. Clignett (deceased)
J.A. Coburn
R.J. Desrosiers
M. Duffield
B. Hanson
E.J. Harrison
R.C.J. Sampson

J.A. Coburn and R.C.J. Sampson played key roles in overseeing the implementation of the system. R.C.J. Sampson also contributed by providing updated information for this paper.

The authors appreciate the support and/or advice provided by others, including G.K. Rodgers, S.H.Whitlow, J.S. Ford, A.S. Watson, J. Rogalsky, and R. Duffield. As well, all of the representatives of Digital Equipment of Canada Ltd. involved, in particular Ian McKinnon, were very co-operative. Finally, the authors would like to thank the Water Quality Branch laboratory staff at Burlington for their constructive criticism, co-operation and patience.

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Environment Canada. 1978. LABS 11 — A Laboratory Data Management System. Inland Waters Directorate, Atlantic Region, Water Quality Branch, Moncton, New Brunswick.