EARTHWATCH

GLOBAL ENVIRONMENT MONITORING SYSTEM

GEMS
REPORT SERIES
NO. 14

NAIROBI
OCTOBER 1992

UNEP/WHO/WMO/UNESCO

GEMS/Water

Report of the RAISON/GEMS Software Expert Review Meeting

May 11-15, 1992, Burlington, Ontario, Canada

United Nations
Environment Programme

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REPORT

OF THE

RAISON/GEMS SOFTWARE EXPERT REVIEW MEETING

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GEMS/WATER

REPORT OF THE RAISON/GEMS SOFTWARE

EXPERT REVIEW MEETING

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REPORT OF THE RAISON/GEMS SOFTWARE

EXPERT REVIEW MEETING

May 11-15, 1992

National Water Research Institute
Canada Centre for Inland Waters
Burlington, Ontario, Canada

EXECUTIVE SUMMARY

INTRODUCTION

RAISON/GEMS is a PC-based software package, developed by Environment Canada, for the UNEP/WHO/WMO/UNESCO GEMS/Water quality monitoring programme, to support national and international water quality data handling and analysis activities.

The Global Water Quality Monitoring Project (GEMS/WATER) was the first programme of its kind to address global issues of water quality through a network of monitoring stations in rivers, lakes, reservoirs and groundwaters on all continents. Through technical cooperation with developing countries, the programme has contributed to the establishment and expansion of national water quality monitoring systems in many countries.

OBJECTIVES OF THE REVIEW MEETING

The international expert meeting was called by UNEP and WHO on behalf of the UNEP/WHO/WMO/UNESCO GEMS/Water programme to:

1. Carry out an Expert Review of the RAISON/GEMS software package and to assess its potential for use within the GEMS/WATER programme.

2. Provide a forum for expert opinion on short and long-term needs by GEMS/WATER for its data programme and for information management technologies that will be required to strengthen both GEMS/WATER within a global context, and individual national water quality programmes.

The meeting was attended by 21 invited experts, selected from around the world and with specific expertise in water data information systems, including GIS technologies. In addition, the UN organizations, participating in GEMS/WATER (UNEP, WHO, WMO AND UNESCO), were represented.

1. REVIEW OF RAISON/GEMS SOFTWARE SYSTEM

BACKGROUND

Country missions by GEMS consultants have highlighted the need for improved data handling, analysis and presentation tools in many developing countries for the purpose of water quality assessment and policy development. GEMS has therefore encouraged the development of low-cost, effective data handling systems suitable for use in developing countries.

The National Water Research Institute of Environment Canada, the manager of the GEMS/WATER Global Databank, has developed considerable expertise in the types of software identified above, including advanced modelling. A basic version of one of the Canadian family of software programmes, RAISON, was adapted for GEMS/WATER purposes and has come to be known as RAISON/GEMS. This software has been field tested in a number of countries, including China and Mexico.

BASIS OF REVIEW

The objective of the expert review was to examine the utility of the RAISON/GEMS software package for the GEMS/WATER programme, not to examine the whole range of packages available. The basis of the review included: technical capabilities; compatibility with the global database; cost; degree of user-friendliness and ease of operation; long-term software support - e.g. continuing development activities at NWRI and the commitment of the Canadian Government; capability of the package to import maps from external GIS sources; production in different languages; and continuing development of the system beyond the present RAISON/GEMS package.

The review of the software took the form of training/demonstrations combined with hands-on applications by the experts. Representatives from China and Mexico reviewed their experience with RAISON/GEMS.

RAISON/GEMS

The Expert Group listed the following characteristics of RAISON/GEMS:

1. It integrates mapping, spreadsheet, database and statistics in a unified software system which is specifically designed for GEMS/WATER applications.

2. It is designed to interface with public domain and commercial software, and specifically in the context of ease of data transfer.

3. It is designed to operate efficiently on a range of micro-computers.

4. The Government of Canada, through its R&D programme in information technology at NWRI, supports and maintains the RAISON software and has made appropriate arrangements to provide ongoing software maintenance and training.

5. Training required for effective use of the software is in the order of three to five days for informed users.

6. RAISON/GEMS is reasonably priced for wide distribution.

7. RAISON/GEMS has potential for use in applications other than GEMS/WATER.

RECOMMENDATIONS

The Expert Group made a number of recommendations concerning both technical and administrative aspects of the software. Technical recommendations included improved interface with GIS software such as IDRISI, improved editing facilities of the database, addition of time scale graphics and time series analysis, improvements to the tutorial, and a unified interface amongst the software components. NWRI can make the necessary changes, with the exception of the unified interface, in approximately six months.

Administrative considerations considered by the Expert Group included: terms of distribution; appropriate cost recovery to ensure adequate maintenance of the software; provision of long-term maintenance of the software; training requirements, including development of regional or national centres; and language capabilities of the software.

Taking into consideration the recommendations noted above:

1. The experts consider that the RAISON/GEMS package is well suited for use in the GEMS/WATER programme for data processing and interpretation at the local, national and international levels and should be disseminated as soon as possible under the GEMS programme.

2. Because of the flexibility of RAISON/GEMS in multi-disciplinary environments, the package be considered by United Nations agencies as an integrating software framework for other types of data, for resource management issues within and beyond the water sector.

3. Specific recommendations were made for additions and improvements in system functionality that should be incorporated in future versions of RAISON/GEMS.

4. Recommendations on distribution of RAISON/GEMS within the GEMS programme included specific references to cost, maintenance, and training.

2. FUTURE GEMS/WATER DATA AND INFORMATION HANDLING

The purpose of the discussion was to examine the critical information, database, and software requirements for achieving the GEMS/WATER goal of strengthening national capacities for water quality management, and to enable the preparation of comprehensive national, regional and global water quality assessments.

Presentations were made by the representatives of the Global Runoff Data Centre (GRDC), the International Lake Environment Committee (ILEC), and the International Reference Centre (IRC) in the Hague, concerning various aspects of information storage, processing and dissemination.

Several of the invited Experts presented demonstrations of decision-support software used in a wide variety of applications. These included a Catchment Management Support System developed by CSIRO in Australia, a variety of advanced packages for groundwater, spill management, climate change, etc., by IIASA of Austria, the QUAL2 model of the US-EPA, and advanced decision-support applications of RAISON by NWRI of Canada.

RECOMMENDATIONS

1. **Scope of Application of the RAISON/GEMS Software:** The Expert Group felt that a typical set-up for implementation of the GEMS programme at the country level would involve the use of the basic RAISON/GEMS package at the regional/local or catchment level, as well as the central water authority level. In addition, the RPL version of the package could be made available to a technical or scientific institution acting as a national reference, training and maintenance centre.

2. **Auxiliary Data Needed by GEMS/WATER:** Relevant information available from other sources such as that in WMO's referral system INFOHYDRO, should be brought into the Global Database. The Global Database would also benefit from the incorporation of information from *selected parallel data bases* containing non-systematic water quality survey information and selected published data, especially from sources not easily obtainable but which can be accessed through the GEMS programme.

3. **Information Packages to GEMS/WATER Participants:** To strengthen the capacity of countries to collect and process information on water quality, GEMS/WATER should prepare a comprehensive country assistance package including manual, AQC information, RAISON/GEMS information, information available from GRID, HOMS and other UN agencies, and an example of the use of RAISON/GEMS such as implemented by Mexico.

4. **Promoting Progress in National Programs:** The Expert Group recommends that the GEMS programme seek means to facilitate the flow of financing with a view to:

   (a) organizing regional meetings aimed at establishing a network of professionals able to provide reliable and compatible data and information, amongst other, to the Global Database,

(b) implementing programmes for standard data entry capabilities at the national level,

(c) Providing a sound database at the national level for the formulation and implementation of sustainable national water quality programs. The expert Group recognizes that the last issue is complex and has broad implications, some of them beyond the scope of the GEMS programme.

5. **Need to Educate Managers in New Interpretive and Decision-Support Technologies:** The Expert Group recognized the need to sensitize water managers to the advantages of using information technology to enhance decision-making for specific environmental issues, and for policy development. This could be achieved by workshops and seminars.

6. **Access to Data:** The experts urged international and bilateral organizations to ensure that the data generated through their technical cooperation programmes be made available to the international community.

7. **Need for Progress in Integrated Water Management Information and Information Technologies:** The Expert Group urges United Nations technical agencies, through the ACC Intersecretariat Group for Water Resources, to address the broader issue of information management and information systems, and their application to sustainable development of water resources at the national and global scales. In this regard, the role of existing and future programmes, such as GEMS/WATER, CESI, WASAMS, GRID, HOMS, GCOS, CLICOM, IHP and others must be taken into consideration.

8. **Lead Role for GEMS/WATER in Information Technologies:** The Expert Group recommended that GEMS/WATER play a lead role in the application of advanced information technology to the integration of water quality and related information both for national water quality programmes and for global network purposes. This requires the examination of types of data sets needed, technical questions concerning access, storage and retrieval, and the development of appropriate decision-support software for national decision-making and global assessment.

GEMS/WATER

REPORT OF THE RAISON/GEMS SOFTWARE

EXPERT REVIEW MEETING

May 11-15, 1992

National Water Research Institute
Canada Centre for Inland Waters
Burlington, Ontario, Canada

I. INTRODUCTION

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The Global Water Quality Monitoring Project (GEMS/WATER) was the first programme of its kind to address global issues of water quality through a network of monitoring stations in rivers, lakes, reservoirs and groundwaters on all continents. Through technical cooperation with developing countries, the programme has contributed to the establishment and expansion of national water quality monitoring systems in many countries.

OBJECTIVES OF THE REVIEW

The international expert meeting was called by UNEP and WHO on behalf of the UNEP/WHO/WMO/UNESCO GEMS/WATER programme to:

1. Carry out an Expert Review of the RAISON/GEMS software package and to assess its potential for use within the GEMS/WATER programme.

2. Provide a forum for expert opinion on short and long-term needs by GEMS/WATER for its data programme and for information management technologies that will be required to strengthen both GEMS/WATER within a global context, and individual national water quality programmes.

The meeting was attended by 21 invited experts, selected from around the world and with specific expertise in water data information systems, including GIS technologies. In addition, the UN organizations, participating in GEMS/WATER (UNEP,WHO,WMO AND UNESCO), were represented.

OFFICIAL OPENING

Dr. R.J. Daley, the Executive Director of the National Water Research Institute (NWRI), officially welcomed the participants to Burlington. He noted the continued commitment of the Government of Canada to the GEMS/WATER programme, and to the development of information technology in general and to the RAISON system in particular. This commitment had, he said, the aim of enabling water resources managers to move away from the present situation of "data rich but information poor". He said that GEMS was providing the means to improve this situation, especially in the developing world, and welcomed the collaborating role of NWRI. He noted the visit of Dr. M. Gwynne, the Director of GEMS, to Canada in the last week as evidence of a continuing dialogue on joint programs.

Dr. V. Vandeweerd of GEMS-PAC, UNEP, welcomed the participating experts on behalf of Dr. M. Tolba, Executive Director of UNEP, and of Dr. M. Gwynne, Director of GEMS. She thanked Dr. Daley and his staff for hosting the meeting and described the importance of NWRI in the past and present activities of GEMS/WATER. NWRI had played a central role in the development of Phase 2 of GEMS/Water and was responsible for the development of the RAISON system. She stressed that GEMS/WATER existed as it does now in large measure due to the efforts of the staff at NWRI. The RAISON/GEMS software package had been developed because of the recognition that the tools for information handling and interpretation needed for effective water quality management were absent in many countries. Governments were becoming more aware of the importance of data interpretation and presentation in making informed management and policy decisions.

Dr. Vandeweerd said that the objective of the first three days of the review was not necessarily to identify whether RAISON was the best system available but to establish whether it could be a cost effective and usable tool for information handling within the GEMS/WATER programme. If it did not meet these criteria, the review should identify what needed to be done. The second part of the meeting was intended to discuss future strategies and trends in the use of information for resource management, including such techniques as GIS, expert systems and modelling. She wished the meeting success in its work.

SELECTION OF CHAIRPERSON AND RAPPORTEURS

The Expert Group, elected Dr. Vandeweerd as the general Chairperson of the meeting, and Mr. P. Najlis and Mr. J. Jackson as rapporteurs. Dr. W. Mooneyhan served as vice-Chairperson for several parts of the meeting.

INTRODUCTION TO GEMS/WATER

Overview, Objectives and Mode of Operation - Dr. R. Helmer, WHO

GEMS/WATER, the Global Freshwater Monitoring Programme, has its origins as a joint UNEP/WHO initiative in the mid 1970's as a follow-up to the Stockholm conference of 1972. During this period, NWRI has played a central role as the WHO "Collaborating Centre on Surface and Ground Water Quality", and has developed and operated the GEMS/WATER Global Database. Other organizations such as UNESCO had provided valuable contributions on training and methodology and WMO co-operated on the integration of water quality and water quantity data. The first phase of GEMS/WATER had made important progress on global network development, methodology, analytical quality control and had published triennial data reports, an assessment of global freshwater quality and other technical material.

In view of changing needs, the programme was reviewed by an expert group in Leningrad in 1990 where the objectives of GEMS/WATER were expanded beyond monitoring with a greater emphasis upon the provision of water quality assessments. This has led to recent publications such as: *Water Quality: an Assessment of Progress in the Implementation of the Mar Del Plata Action Plan and a Strategy for the 1990's* which was developed for the World Conference on Water and Development held in 1992. Methods of assessing water quality data, *Water Quality Assessments*, was published in 1992. The third edition of the *GEMS/WATER Operational Guide*

will be published in the next several weeks. GEMS/WATER has the continuing aim of strengthening national water quality programs, particularly on a river basin scale with current initiatives underway in the Nile, Niger and Zambezi basins, amongst others. In addition, the global network is being expanded to include stations that will permit examination of fluxes of nutrients and pollutants from major river basins to the sea.

Water resources issues have traditionally occupied a relatively low place on the international agenda but this situation is now changing - the recent Dublin conference was an example of this. Dr. Helmer cautioned that current progress in data handling and presentation meant that for many developing countries, the technology for handling data had overtaken their capacity to produce reliable data. The consequence is that operational considerations and analytical quality control lagged behind. Dr. Helmer expressed concern that while data could be presented well, it might be of dubious quality. Nevertheless, the development of data handling and production of information was of great importance in that good communication is an essential element in the strengthening of monitoring and assessment programmes.

DISCUSSION: Two requests for support which are commonly received by GEMS/WATER from developing countries were highlighted -- analytical quality control protocols, and information handling software. Many countries had, at best, only archiving facilities which were not suitable for data analysis or for effective communication as a basis for decision-making.

A PARTICIPATING COUNTRY PERSPECTIVE
Ing. O. Natale, INCYTH, Argentina

Argentina at present has no national water quality programme or water quality monitoring network but there are a number of regional and basin-level water quality programmes. The countries of the La Plata River Basin (Argentina, Bolivia, Brazil, Paraguay and Uruguay) co-operate on the use and management of the river. This includes pollution control and a co-ordinated water quality monitoring programme operated by several of the riparian countries. Water quality issues include untreated domestic sewage, industrial effluents and problems associated with hydropower developments.

Approximately 30% of Argentina's electricity is generated by hydroelectric power. The reservoirs which supply these plants are used for water supply, navigation and irrigation in addition to power generation. Eutrophication, heavy metals and pesticides are of concern in the reservoirs. Monitoring programmes are in place on several reservoirs.

In addition to routine monitoring of certain water bodies, case studies have been conducted in Argentina to examine particular water quality problems. Two examples were given - a four year project to examine the levels of organophosphorus pesticides in the Rio Negro and a study of hydrocarbons in the Rio Parana.

Argentina participated in Phase I of GEMS/WATER but activity was limited by the absence of a national monitoring network, by shifts in responsibility between national agencies and by limited interest in global water quality issues. However, Argentina did benefit from GEMS/WATER support activities.

The Instituto Nacional de Ciencia y Tecnica Hidricas (INCYTH) developed a data storage and retrieval system (CADAGUA) for data generated by the various monitoring networks. CADAGUA is based upon the Canadian NAQUADAT system and consists of dictionary, stations, data, tables, computation and graphics subsystems, operating on a mainframe computer. By 1990, there were more than 30,000 water quality data entries in the system. A similar system, PLATA, holds data for the La Plata program. There is a demand for better systems which have better analytical capabilities, including GIS and some form of expert systems for use in water quality data evaluation and presentation.

DISCUSSION: Both water quality and water quantity are measured for the La Plata River Basin. The data are held by different agencies in each country of the basin and the International Commission of the La Plata River Basin. Most of the La Plata River Basin stations are situated on shared reaches of the river.

II. REVIEW OF THE RAISON/GEMS SOFTWARE

1. RAISON/GEMS: Overview and Evaluation Criteria - Dr. V. Vandeweerd, UNEP

Country missions by GEMS consultants have highlighted the need for improved data handling, analysis and presentation tools in many developing countries for the purpose of water quality assessment and policy development. GEMS has therefore encouraged the development of data handling systems with the following requirements:

1. National and local authorities can analyze and display their water quality data.
2. Limited GIS capabilities with links to full GIS programmes such as GRID.
3. Ability to easily interact with other commercial and public domain software.
4. Low in cost and non-commercial.
5. Suitable for types of PC hardware found in developing countries.
6. Compatible with the GEMS global database to facilitate data handling and transfer.

In the course of the development of the RAISON family of programmes, NWRI had developed considerable expertise in the types of software identified above, including advanced modelling. From this group of programmes, the basic version of RAISON was adapted for GEMS/WATER purposes and has come to be known as RAISON/GEMS.

The objective of the expert review was to examine the utility of the RAISON/GEMS system to the GEMS/Water programme, not to examine the whole range of packages available. The considerations of the RAISON/GEMS review should include:

1. Technical capability
2. Compatibility with the global database.
2. Cost.
3. Degree of user-friendliness and ease of operation.
4. Long-term software support - e.g. continuing development activities at NWRI and the commitment of the Canadian Government.
5. Capability of the package to import maps from external GIS sources.
6. Production in different languages.
7. Continuing development of the system beyond the present RAISON/GEMS package.
8. Training support availability.
9. PC environment.

2. RAISON: Background - Dr. E. Ongley, NWRI

RAISON ("Regional Analysis by Intelligent Systems ON a microcomputer") originated some six years ago in response to a need for an integrated information management package that included database management, GIS and prediction capability for Canada's acid rain programme. The package that has become RAISON/GEMS was largely developed over the following four years and included database and spreadsheet capabilities, sufficient capability in GIS that it could manipulate, store and display geo-referenced data, and an analytical capability for examining the database. For the acid rain programme, RAISON also included modelling capability; this aspect has become the basis for subsequent applications in environmental analysis using a variety of numerical and expert systems approaches.

RAISON/GEMS is the "low-end" component of the RAISON family of software. It is primarily adapted to low-end machine capabilities that are typically found in developing countries. It does not include the modelling capability of advanced versions of RAISON. RAISON was adapted to the GEMS programme in order to respond to information management, analysis and interpretive needs typical of developing countries.

RAISON is **primarily a numerical tool** with sufficient GIS capability to permit effective use of geo-referenced information. RAISON is fully compatible with most commercial GIS systems such as ARC-INFO and SPANS and with spreadsheet systems such as Lotus.

RAISON is currently made available, under license, in two forms. One, the RAISON/GEMS package, is the low-end version which cannot be used for modelling. This is designed for 386/486-based PC's with 4MB RAM. A stripped-down version is available for 286, 1MB machines. The second form is a full modelling version which includes the RAISON Programming Language (RPL) which permits the user to customize the software for virtually any type of application. RPL is our answer for user flexibility while maintaining the integrity of the source code.

RAISON is an ongoing R&D programme of the National Water Research Institute in response to Environment Canada's needs for improved information technologies. Much of the current R&D is focused on interfacing data and information with decision-making and policy development. The RAISON software is owned by the Government of Canada.

Because NWRI is an R&D establishment, it is not funded to carry out routine software maintenance. In order to ensure maintenance and orderly distribution of RAISON, the Government of Canada has entered into an agreement with ES Aquatic Inc. of Guelph, Ontario, for licensing and maintenance of the RAISON software. The principals of ES Aquatic have been part of the RAISON development process since the inception of the RAISON programme.

Distribution to the non-profit institutional market is based on a not-for-profit license fee which covers the real costs of software maintenance. Currently, the institutional license for RAISON/GEMS is a one-time $C 850 fee. This is time-limited and does not include major upgrades. The license for the RPL version of RAISON is now $C 5000 for institutional clients.

None of these fees cover training costs. Fees to the private sector and commercial applications are higher.

Training is made available, at cost, based on a negotiated fee structure with ES Aquatic Inc.. Full instructions in RAISON/GEMS can be covered in one week, with up to eight trainees per instructor. This is usually done in the recipient country. Training in RPL applications is more lengthy and is usually carried out in an R&D setting involving both ES Aquatic and NWRI. The objective within GEMS/WATER is to identify a centre of excellence in national programmes that can take over in-house RAISON/GEMS training in that country.

DISCUSSION: Between 50 and 100 copies of RAISON/GEMS are currently in use; licensing arrangements were established in the autumn of 1991 and more active distribution is now intended. The participants commented on the low licensing cost of $850, asking whether this allowed a viable future for the package. Dr. Ongley believed that such a pricing structure was probably reasonable with certain constraints but that the license cost was not yet fixed. The cost of more advanced versions for non-profit institutional users is in the region of $5000 but few countries yet needed such capabilities. RAISON will shortly be capable of running in a work station environment.

The question of the license fee covering future programme support was illustrated by the experience of UNITAR with IDRISI, which had a non-profit license set at $150. This had allowed efficient support for up to 3000 copies but at the present distribution of 5000 copies, responses were slower and more bugs were appearing. NWRI intends to avoid such problems by ensuring an adequate cost-recovery to maintain the software.

Training costs are not included in the license fee. It is usual to train in the country where the programme will be used and, normally, one week of training is needed. One trainer can train 8-10 people with two people per computer - costs include salaries, per diems, and travel. Training is currently a joint activity of NWRI and ES Aquatic.

3. RAISON/GEMS: Technical Review

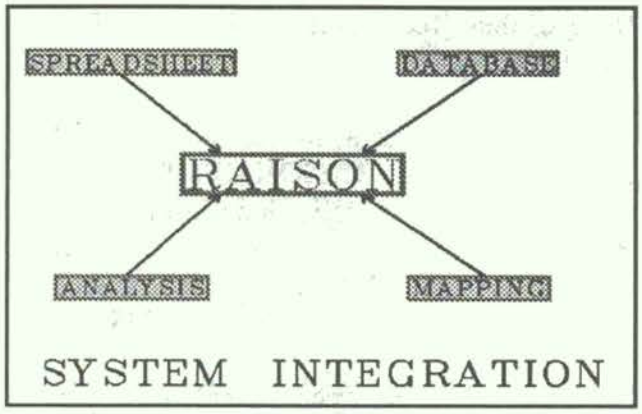
3.1 RAISON/GEMS Technical Overview - Dr. D. Lam, NWRI

The objectives of the RAISON development programme have been to develop software systems for:

1. Regional analysis of environmental data, and
2. "Intelligent" application of expert systems and models

Six years ago, NWRI was asked to combine over 20,000 data records on water quality, deposition, land use and ecological information for evaluation of the acid rain problem in Canada. There were two possible approaches to this task. The first was the individual approach - to buy individual software packages (GIS, databases, spreadsheets) which could be used together to do

the required job. The problem with such an approach was that probably only a small portion of each package would be used and that some required functions would be missing. In addition, the transfer of data and information between the packages was difficult and inconvenient. The second approach to the task of data combination was the RAISON approach which aimed to build from scratch an integrated system with all essential features of GIS, database, spreadsheet and statistics. Such an approach would be specially designed for environmental applications, so that information and data could be freely accessed and used. It would also allow input and output to other existing software systems.



The features of RAISON, as it has now developed, are as follows:

* it employs micro-computer technology, requiring an IBM-compatible 386/486 machine (minimum 386/20MHz with math co-processor), DOS 3.1 or newer, hard disk 10 Mb or above, 1.44 Mb 3.5" diskette drive and VGA graphics (640 x 480, 16 colour).

* it is relatively inexpensive.

* it integrates a number of different software functions.

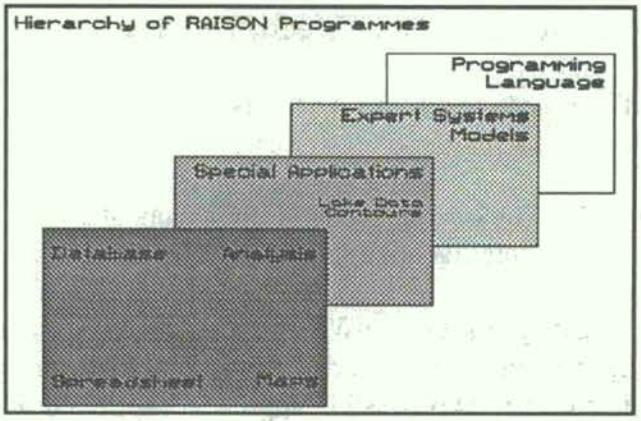
* it is compatible with popular software.

* it is flexible and user friendly.

* it can be customised to adapt to new problems or requirements.

* it is backed by experience in maintenance and training (now through a licensing system).

Beyond the basic version of RAISON/GEMS, with its four elements of database, analysis, spreadsheet and mapping, the RAISON family of programs extends successively to special applications including contouring and limnological applications, expert systems and models using the RAISON Programming Language (RPL). RPL is a custom designed language used to manipulate the RAISON system for customized and batch operations.



3.2 RAISON/GEMS Spreadsheet - Mr. A. Fraser, NWRI

The RAISON/GEMS spreadsheet facility has been developed to fulfil a number of functions. It performs data retrieval from the database and then acts as a platform for further analysis. The spreadsheet acts as a statistical interface and can present data and statistics for other functions such as graphical display and datamapping. Data import and export are included and the spreadsheet is integrated with the database. At more advanced levels, the spreadsheet can perform keyword searches, has hypertext capabilities and can act as an expert systems interface.

In more detail, the characteristics of the spreadsheet are as follows:

* Fully functional spreadsheet containing all standard features of advanced commercial packages.

* Integrated fully into other components of the RAISON system.

* It is the main system component for data retrieval, analysis and assessment.

* Can be configured by local or global variables to fit the requirements of the user.

* Will accept data of mixed format -- particularly valuable for multi-disciplinary studies.

* Conditional retrievals are made using logical construct filters to bring only those data required into the spreadsheet from the database.

* Interfaced fully to statistics module, graphical presentation facility, and mapping structures.

* RAISON system moves between modules such as spreadsheet, statistics and mapping system seamlessly, i.e. if working in the spreadsheet the user can move to the mapping system and then return to the spreadsheet without losing data.

* Standard import/export facility supporting major commercial packages with both fixed and delimited format.

* Spreadsheet is the main control centre where assessment activities are undertaken.

* Formulae and functions may be placed in spreadsheet cells.

* Number of rows: 8192, Number of columns: 256, current limits.

* Flagged data such as L, G, F, etc. are acceptable within database and do not inhibit use unless specified by users.

* Multiple databases may be accessed and data retrieved into a single spreadsheet. This is invaluable when multi-disciplinary studies are undertaken, e.g. water chemistry, forestry.

Data types supporting multi-disciplinary studies include a date field that allows time series data to be handled as a parameter for analysis. The ability to define a variable as an "ACTION" field permits key word activation of other system modules or run macro routines.

CHARACTER	DATE	ACTION
NUMERIC	LOGICAL	SCIENTIFIC

The capabilities of the spreadsheet were demonstrated with data from GEMS/WATER stations in China.

File Worksheet Statistics Graph DataMapping Utilities Quit
Load,Save,Directory,Import,Export,Retrieve

	A	B	C	D	E	F	G	H	I
1	CRN	CSN	PSN	LAT	LNG	DATE	TIME	SD	DP
2	9122042	2	001	43.313889	79.750556	91/08/12	1509	27	1
3	9122042	90	085	43.749167	79.085	91/08/16	707	46.3	1
4	9122042	35	087	43.298611	77.518889	91/08/14	25	37.2	1
5	9122042	74	062	43.878333	77.000833	91/08/15	1357	11.5	1
6	9122042	11	015	43.383333	79.285	91/08/13	52	104	1
7	9122042	68	079	44.075	76.521111	91/08/15	756	22.5	1
8	9122042	58	097	43.961667	76.127222	91/08/14	2356	12.6	1
9	9122042	64	101	44.195	76.3125	91/08/15	347	21	1
10	9122042	69	001	44.016944	76.671389	91/08/15	852	36.8	1
11	9122042	59	070	43.541944	76.211778	91/08/14	1451	158	1
12	9122042	62	078	44.004167	76.416111	91/08/13	234	22	1
13	9122042	13	086	43.254167	79.193333	91/08/13	231	12.2	1
14	9122042	49	069	43.606944	76.713333	91/08/14	1358	180	1
15	9122042	78	048	43.860556	77.524167	91/08/15	1814	23.8	1
16	9122042	89	027	43.702778	78.957222	91/08/16	610	98.7	1
17	9122042	40	059	43.3825	77.298333	91/08/14	425	180	1
18	9122042	19	025	43.516389	79.080556	91/08/13	725	134	1

</>Menu <F2>Edit <F6>GOTO <^Y>Del <^R>Recalc

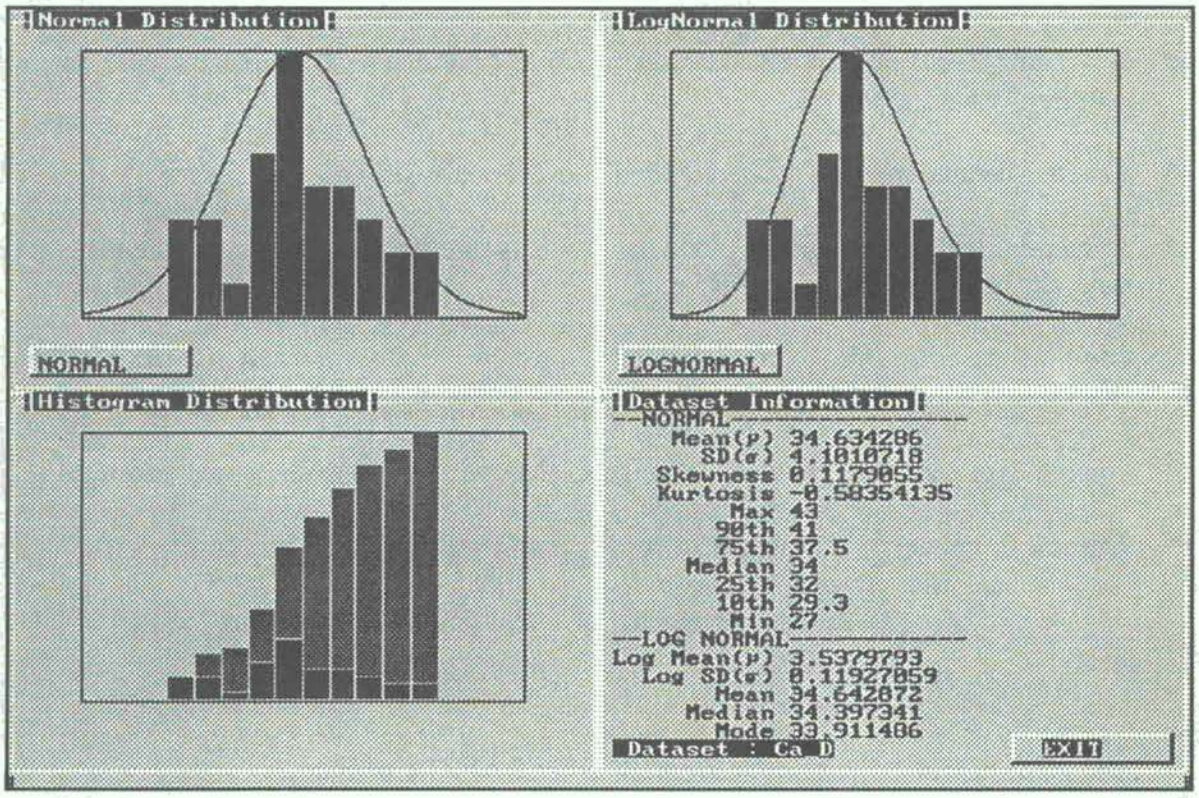
DISCUSSION: The maps displayed were taken from Worldbase 2, only using the top 30% of detail. RAISON does not yet use CD-ROM but this would be the next step in incorporating digitized material. It was suggested that some information might be included on the appropriate use of spatial data. The limits of the spreadsheet were discussed and it was suggested that within the limits of spreadsheet area, more flexibility in the number of rows might be considered to

increase the number of columns, or vice versa. It was stressed that the system assumes use by an informed user who knows the appropriate use of various techniques. The advantage of the RAISON/GEMS spreadsheet advantage over conventional packages lies in its integration with statistical, graphical and mapping. The mapping functions of RAISON/GEMS are flexible - new digitized maps can be added and new snapshots defined.

3.3 RAISON/GEMS Statistics - Dr. D. Lam, NWRI

A number of statistical functions were considered for the RAISON/GEMS system. Basic functions (mean, median, standard deviation, etc.) have been implemented along with parametric tests of means and variances, and non-parametric sign test, signed rank test, rank correlation coefficient and run test. Linear regression is included as part of x-y plot functions.

The salient feature of this component in the RAISON spreadsheet is that data can be accessed easily from database or spreadsheet. The analysis can be done quickly and the results, including graphs, can be saved and output as hard copy or exported to a word processor for reporting.



Both normal and lognormal distributions are offered with accumulative information. Standardized boxplot of the distribution showing minimum and maximum, 10th, 25th, 50th, 75th and 90th percentiles can be constructed. These can be used, for example, to compare the long-term distribution with individual year distributions.

Time series data can be displayed with reference levels (e.g. a line showing long-term mean). Tests of means, for example, can be performed to see if individual year data conform to some known long-term mean, depending on the normality of the data.

Tests for correlation and/or regression can be constructed and the results compared. Tests for randomness in the data are also implemented.

In summary, the statistics in RAISON/GEMS offer the basic functions for testing data, finding distributions, time series analysis, spatial distribution and boxplot. It is particularly convenient to bring data from database and spreadsheet, and to output results to external packages for further processing (for example in report preparation).

DISCUSSION: The possibility of saving intermediate statistical results was suggested. It was also suggested that the package should include the possibility of storing standard pathways of statistical procedures. It is possible to screendump to printers from the statistics module and the results can also be moved into word processing packages or to more complex graphing packages.

3.4 RAISON/GEMS Database - Mr. A. Fraser, NWRI

The database of RAISON/GEMS is adaptable and flexible, storing and retrieving data as required and interacting with the other modules of the package. The specific characteristics are:

* A schema based system. i.e. the user constructs the database template according to the requirements of a project.

* Schema layouts may be created, edited and deleted easily.

* In creating a database, mixed mode data such as integer, real, character, scientific, fixed, date, etc. may share the same schema.

* Multiple database files can be joined to provide easy access and retrieval for multi-disciplinary studies.

* Import/Export facility enables exchange of data with major commercial packages.

* Current limits per: database file
  - number of records: 2×10^9
  - record size (bytes): 16,383
  - fields per record: 100 (to be expanded to 255).

* On screen help facility provided.

* Database module is accessible from all other RAISON modules.

* Function of RAISON database is to provide a location for data to be used by all other RAISON modules.

* Low level of data manipulation inside the database because other RAISON modules seamlessly interface with database structures for manipulation, retrieval and analysis.

* Data may be reviewed, added and edited with full screen display.

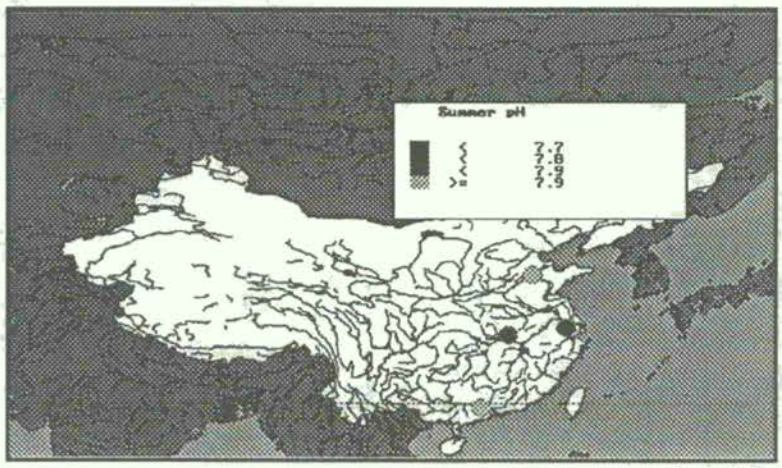
DISCUSSION: The use of -99.9 as the default value was discussed - no problem had yet been encountered and this flag designation can be set by the user. It was suggested that one user interface be used for all of the modules - this was considered a good idea by the NWRI staff.

3.5 RAISON/GEMS Datamapping - Dr. D. Lam, NWRI

Datamapping is a special function in the spreadsheet to perform integration of map, database and spreadsheet. Primarily, it is designed to permit interpretation of site specific numerical data within a geo-referenced context. For example, data for a chosen parameter can be brought in from the database to the spreadsheet for several sites. Each site may have time series data for

which statistical analysis can be performed and the mean, median, sum, maximum or minimum can be chosen to represent the station value. By assigning colours for different ranges of values at the stations/sites, the analysis results can be shown on the map.

Temporal, spatial, and parameter constraints can be made for data retrieval. In the site menu, the polygon group function is used to group sites together so that the spatial domain can be selected by the user. Data can be retrieved from database for the chosen sites and can be subjected to further time constraints (e.g. the user may specify summer values only). In addition, data may be chosen for conditions specified for other parameters (e.g. temperature > 15 degrees).



Keyword searches are similar to datamapping except that the search is for user-specified keywords or phrases so that those sites containing them will be colourised on the map.

In summary, these functions in RAISON/GEMS provide the tools for manipulating data for a given parameter in space, time, and conditions affected by other parameters. The integration is easy and convenient and the results can be saved as hard copy, screen file or exported to external packages (e.g. Wordperfect, Coral Draw) for report preparation.

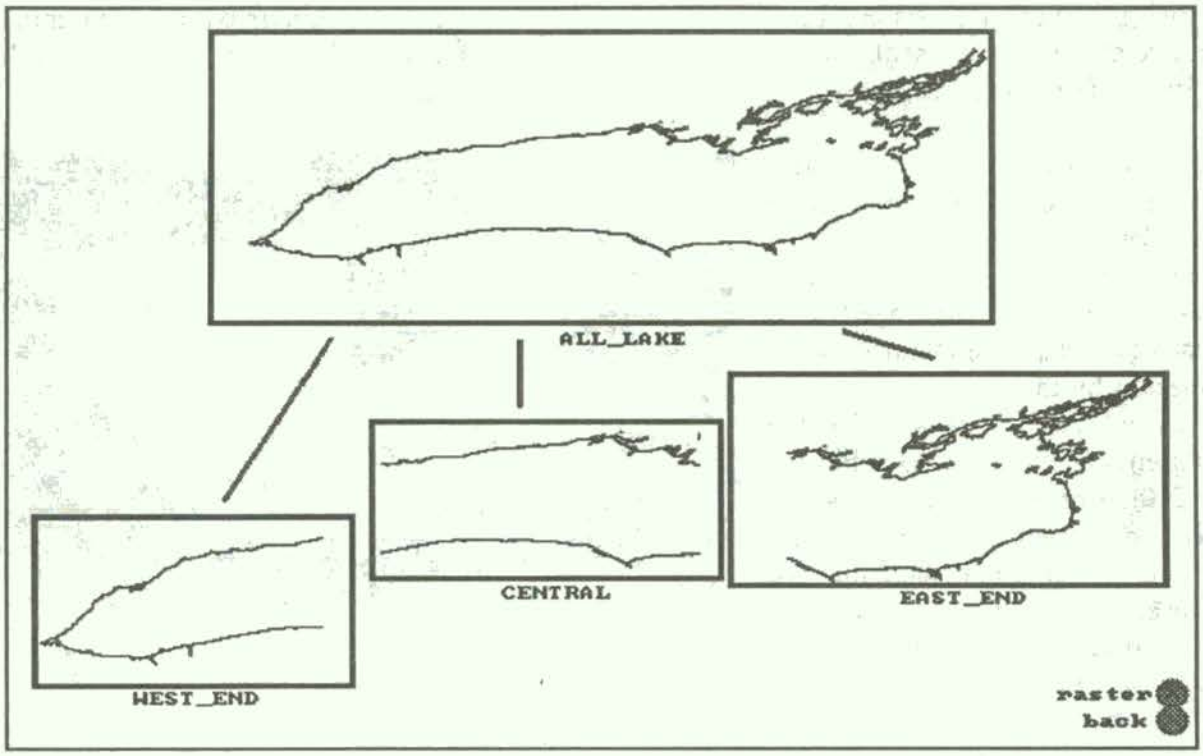
3.6 RAISON/GEMS Maps - Dr. D. Swayne, ES Aquatic Ltd.

This presentation described the map subsystem of RAISON/GEMS, from the creation of a project map to the installation of site data. Map coordinate systems and map projections were discussed, and the possible sources of maps for RAISON/GEMS projects enumerated.

The RAISON/GEMS system can be used for different applications. Each application can easily be constructed by defining a new project. The starting point for setting up a new project is the preparation of a primary graphic, usually a map which becomes the primary project map.

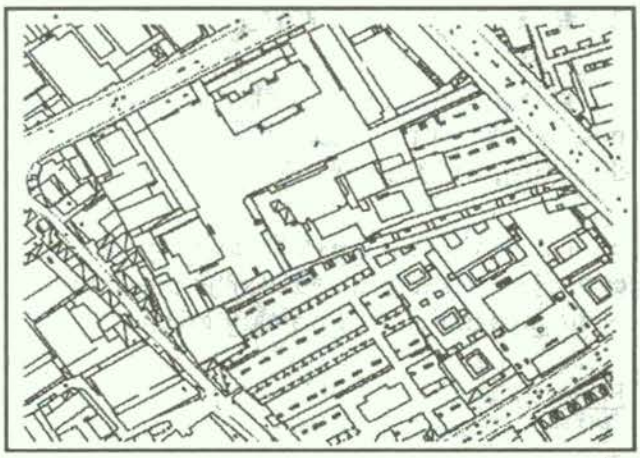
Project Maps

Project maps are the control and entry point to the system. As the RAISON/GEMS graphics system is principally raster based to produce high speed graphics presentation, the use of and conversion of vector map files was discussed and demonstrated. As an example, the steps to create and install raster maps from vector map files using a map of Lake Ontario, a sub-map of Toronto and an hypothetical sampling site in Toronto Harbour were shown.



The ability of georeferencing to give correctly placed sites on different map views was demonstrated. Coordinate systems (Universal Transverse Mercator and Latitude/Longitude) and projections (some 25 of which have been investigated) were discussed. Detailed map construction topics also included: raster maps (RAISON's format) and vector maps (for full GIS) graphical editing.

Sources of geographic vector maps such as Arc-Info and AutoCad were discussed. A sample AutoCad (DXF) file of Shanghai, China was displayed. RAISON/GEMS handles files from other systems through the import utility. Conversion between Lat/Long and UTM was also demonstrated showing full capability of RAISON/GEMS to work in both systems. The RAISON map configuration file, showing the labelling of 17 map features, and the RAISON/GEMS graphics editor, a full featured drawing package was displayed.



Access to other maps in a project, and site information including data, is achieved through the use of map icons. There are two types of icons used in the RAISON/GEMS system. Type one is a symbol to represent another area of a map. Using this type of icon accesses another raster image (snapshot) typically representing a map of different resolution. Icons can be placed anywhere on the screen and can be structured to point to any graphic. Icon creation and placement was shown to link a higher resolution map of Toronto harbour to a Lake Ontario map.

The other type of icon is specifically related to site information and data. The region files (site description) and database files are linked together through the icon add/edit facility. Site locations may be positioned by hand or they may be input through a database import or from a spreadsheet. The site and map icon layouts must include Lat/Long or UTM coordinates. A project must be consistently all lat/long or all UTM throughout the project.

Map Digitization

In any system where map information is presented the availability of digitized vector data for map representation is a concern. The RAISON/GEMS system can handle both digitized Lat/Long and UTM information and therefore, with good map digitization, maps can be properly represented. All systems encounter problems when a map is digitized from older paper or mylar maps whose projection is uncertain. Problems also occur when locations of sampling stations are uncertain. Overlay of map features which is also very dependent on consistency in map structure, was also identified.

Area calculation based on polygons is an important aspect of the map system. Area calculations have been developed. This feature was discussed but is not installed in the RAISON/GEMS demonstration system.

In Summary:

* The map system is designed for easy use through point and shoot menus.

* The use of icons allows rapid and efficient movement between elements of a project.

* The functionality is well suited for data management and analysis with several options for map import and export for external formats.

* The map system is a very powerful tool for structuring and implementing projects.

Projections suggested for use in RAISON

1. Latitude/Longitude
2. Universal Transverse Mercator (UTM) with six degree zones
3. Lambert Conformal Conical with two parallels
4. Cylindrical equal-area
5. Robinson's
6. International Map of the World on the millionth scale
7. Mollweide's

Map Projections Discussed

1. Latitude/Longitude
2. Universal Transverse Mercator (UTM)
3. Modified Transverse Mercator (MTM)
4. Mollweide
5. Robinson
6. Polar gnomonic
7. Oblique gnomonic
8. Transverse gnomonic
9. Polar (normal) stereographic for North polar area
10. Transverse stereographic
11. Oblique stereographic
12. Normal orthographic
13. Transverse orthographic
14. Oblique orthographic
15. Polar azimuthal equidistant
16. Lambert's equivalent cylindrical
17. Lambert's equivalent azimuthal
18. Alber's
19. Stereographic meridian projection of a hemisphere
20. Interrupted Mollweide
21. Zenithal equal-area projection. Net of one hemisphere.
22. International map of the world on the millionth scale.
23. Bonne's
24. Cassini-Soldner
25. Lambert Conical Normal Conformal with two parallels

4. PRESENTATION OF ADVANCED RAISON SYSTEM FUNCTIONS

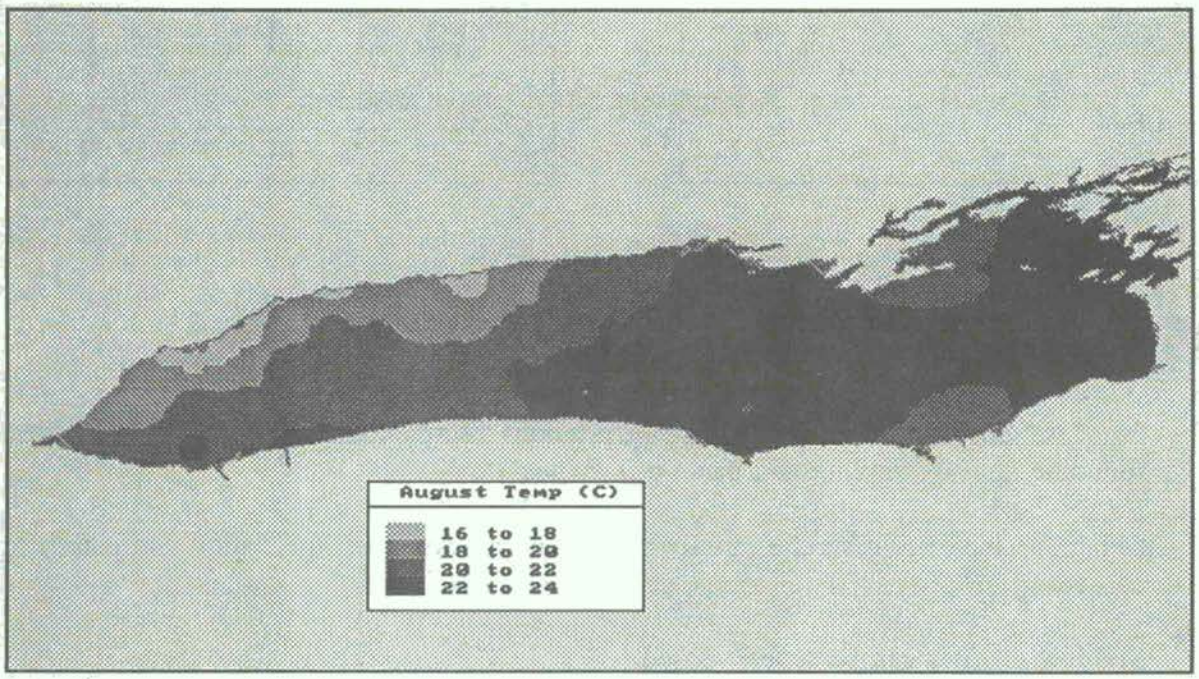
The following "advanced" functions were presented in order to determine the potential value within the RAISON/GEMS package.

4.1 RAISON: Contour Overlay - Dr. D. Lam, NWRI

RAISON/GEMS datamapping can be generalized from a point value to a region for example, after defining the representative value (e.g. median) for each site, the representative value can be defined from all sites within the region. When many regions (e.g. river basins) are involved, colouring the regions on a map according to classification of data ranges can be performed.

Alternatively, instead of using one colour for a region with many sites as for the datamapping, the RAISON contouring procedure uses multi-colour contours (fill or line). First, the values at the sites are interpolated onto a grid, by either one of two methods - inverse distance or kriging.

With kriging, the error limits can also be determined. In RAISON, data from the database can be transferred to the spreadsheet and, using contour functions with user-specified options, the contours can be drawn. The data are not limited to water quality parameters - others such as air quality and ground water data can also be contoured.



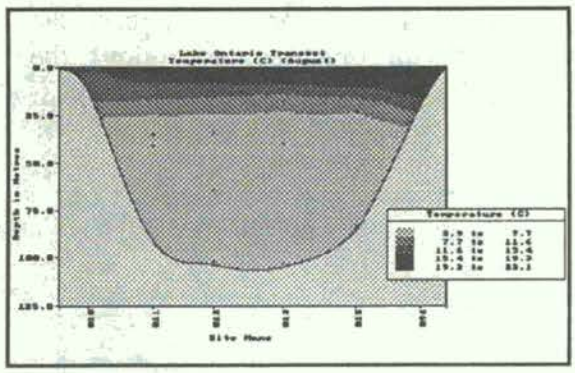
RAISON can also perform simple overlay (intersection/union) analysis with user-friendly interfaces.

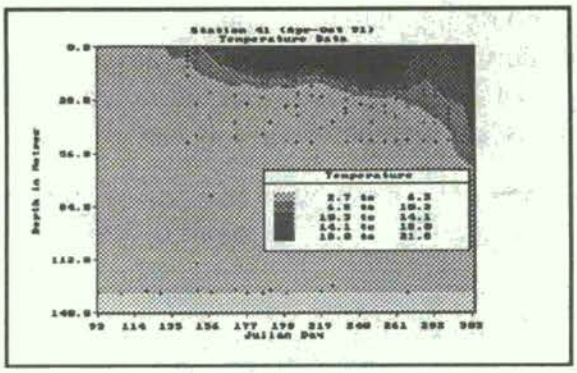
In summary, the contour overlay functions belong to special applications and are currently not included in the RAISON/GEMS package. However, this capability can be incorporated into the RAISON/GEMS system should there be demand.

DISCUSSION: Compatibility of RAISON graphics file structures to other commercial formats was discussed. Clarification that RAISON files can be saved in three formats; PCX for export to other commercial systems ; SCN; and an overlay format, which is specific to RAISON.

4.2 RAISON: Limnological Module - Mr. A. Fraser, NWRI

The limnological module is an extension of the contouring capability of RAISON through which lake stations are displayed by the RAISON image system. This extension of the RAISON system allows details to include depth of sampling and morphological information on sampling sites. Profile information is very useful in evaluating and assessment of lake conditions.





The main characteristics of the limnological module are as follows:

* Database retrieval to spreadsheet module provides discrete data including station location, sounding depth, sampling and parameter values.

* Depth/Parameter profiles are rapidly computed and displayed for station and parameter chosen.

* Multiple profiles can be superimposed.

* Transects can be constructed by selecting any 2 points on shore and as many lake stations as desired by the user.

* Vertical and horizontal gridded interpolation proceeds with displayed results colour contoured to users interval selection.

* Fully functional control over interpolation scheme.

* Scales and legends within users control.

* Depth/Parameter/Time profile for a selected station.

* Choice of station and parameter remains with user.

* All imagery may be edited by fully functional RAISON Graphics Editor for publication purposes.

* Because the RAISON database is capable of handling mixed mode multi-disciplinary data, this module can also be used for groundwater, hydrology and other studies such as soil profiles etc.

* Very flexible in use and application to a wide variety of applications requiring 3-dimensional evaluation and assessment.

DISCUSSION: At present, lake transects must run through a series of selected stations but it is possible that three-dimensional interpolation would be possible in the future to allow any transect to be chosen, regardless of whether it ran precisely through monitoring stations. The module could also be adapted to demonstrate spatial heterogeneity in river transport fluxes.

4.3 RAISON/GEMS -- Additional Technical Information -- NWRI Staff

RAISON capabilities beyond RAISON/GEMS include special and advanced applications such as higher-level statistics, atmospheric applications, the RAISON Programming Language (RPL), and Expert systems applications.

Import and export capabilities of RAISON/GEMS are as follows:

Import from:
- dBase III .DBF files (S,D)
- Lotus 123 .WK1 (up to version 2.1) files (S)
- Text files; both delimited and fixed field formats (S,D)
- .PCX format graphics images (G)
- AutoCAD .DXF vector files (M)
- ARC/Info vector files (M)
- TYDAC digitized vector files (M)

Export to:
- dBase III .DBF (S,D)
- Lotus 123 .WK1 worksheet file format (S,D)
- Text file; both delimited and fixed field formats (S)
- .PCX format graphics image file (G)

*(S)=spreadsheet (D)=database (G)=graphics editor (M)=map system

Many spreadsheet programs export to Lotus .WK1 format files and also to dBase III .DBF file format (such as Quattro Pro and VP Planner). Several database programs (such as FoxBase) use a dBase III compatible file format. These can be directly imported into the RAISON/GEMS spreadsheet module.

Many vector drawing packages have the ability to convert to Autocad's .DXF format (such as Generic CAD). This gives compatibility with such programs if they are used to digitize maps for input into RAISON/GEMS.

RAISON/GEMS can also import data through text files in both fixed field and delimited field formats. This enables importing from almost all spreadsheet, database and modelling software.

Another feature of the RAISON system is in the ability to incorporate character generated text in the map editing module. An example of this capability would be the use of chinese characters for multi-lingual applications. Interest has been shown in the development of specific language versions of the RAISON system (eg. French, Spanish).

5. RAISON EXPERIENCE IN SELECTED GEMS/WATER PARTICIPATING COUNTRIES

5.1 MEXICO - Ing. Luis Leon, IMTA, Mexico

RAISON was used for water quality assessment on one of the most important river basins in Mexico, the Lerma-Chapala system. This river basin covers 54,000 km2 - its main reach is the Lerma River with a length of 700 km which eventually discharges into Lake Chapala. Data from 23 sampling stations on rivers and 28 sites on Lake Chapala were input to RAISON, which contained previously digitized georeferenced maps. Data from 1975-1992 for 18 variables were analyzed and manipulated within the RAISON system produced the results presented after 3 months work. Information was presented as statistical distributions and georeferenced colour contours suitable for problem identification and policy development.

A sampling programme for heavy metals was designed with RAISON using information from inventories of industrial locations which gave information on the different types of industry and their distribution in the basin. The knowledge of the industrial activities and the potential metal contamination of effluents supports the selection of sampling sites with respect to specific contaminants. Data were obtained for 55 cities with more than 5,000 inhabitants and for 1,340 industrial units in 16 categories. These data were manipulated through the RAISON Programming Language to produce map displays and other outputs as the basis for decisions on monitoring station locations.

5.2 CHINA - Mr. ZHU Yudong, NEPA, China

Training in RAISON/GEMS was held in China in 1991, with one week in Beijing for eight participants from the Ministries of Health, Water Resources, and the National Environmental Protection Agency, and one week in Shanghai for participants from other agencies elsewhere in China. Several projects attempted to use RAISON after the training. Some water quality data are imported from existing dbase III; some maps are input by digitizing, and screens with Chinese characters were captured by the graphic function of RAISON and map icons were installed to connect them. Several improvements for use in China were proposed: include several basic projections so users can select a suitable one for different applications; improve map editing functions; and develop a Chinese version of the package.

6. DISCUSSION OF THE RAISON/GEMS PACKAGE

The Expert Group identified the following advantages of RAISON/GEMS:

1. It integrates mapping, spreadsheet, database and statistics in a unified software system which is specifically designed for GEMS/WATER applications.

2. It is designed to interface with public domain and commercial software, and specifically in the context of ease of data transfer.

3. It is designed to operate efficiently on a range of micro-computers.

4. The Government of Canada, through its R&D programme in information technology at NWRI, supports and maintains the RAISON software and has made appropriate arrangements to provide ongoing software maintenance and training.

5. Training required for effective use of the software is in the order of three to five days for informed users.

6. RAISON/GEMS is reasonably priced for wide distribution.

7. RAISON/GEMS has potential for use in applications other than GEMS/WATER.

The participants divided into two groups to discuss and assess the RAISON/GEMS package. One group discussed administrative issues such as distribution, cost, maintenance and support while the other group addressed the technical aspects of the RAISON/GEMS package and the need for additional facilities or modules within the package.

6.1 TECHNICAL RECOMMENDATIONS

The recommendations were placed in three categories - the requested functionality of the RAISON/GEMS package, recommended improvements, and implementation.

1. <u>RAISON/GEMS: FUNCTIONALITY</u>

Currently the RAISON/GEMS package includes the existing database, spreadsheet, statistics and mapping elements. Initial modifications should include overlay and contouring, and limnological functions which are easily added.

2. Recommended Improvements to RAISON/GEMS

a. The map module should interface with other software such as IDRISI to facilitate digitizing, GIS applications and vector updating. More map projections should be included and transforms made possible.

b. The database should include improved editing facilities and clear specification of import and export formats (see below : RAISON/GEMS as an Interface).

c. The spreadsheet should incorporate time scale graphics and special functions should be explained in the tutorial.

d. The statistics module should incorporate time series analysis, a graphics editor and on-line guidelines for proper statistics application.

e. General: - online help should be included, the user interface should be unified for the various modules and linguistic adaptations should be made available.

It was estimated that the technical modifications recommended by the Expert Group for RAISON/GEMS, apart from the unified interface, could be completed in approximately six months. Within this time frame, a modified package may have some bugs but could be distributed; these bugs would be corrected by NWRI at no additional cost to RAISON/GEMS license holders.

3. Recommendation on Technical Implementation

a. It is recommended that the National Water Research Institute (NWRI) of Environment Canada should proceed with the technical development of the system, including translation to other languages, and maintain the basic RAISON/GEMS package.

6.2 RECOMMENDATIONS on ADMINISTRATIVE ISSUES

RAISON/GEMS as an Interface: The participants identified that the flexibility of the RAISON software gave it a great deal of potential as a tool for integrated information management. This integration is extremely valuable for bringing together various sources for water resource management, and/or providing an interface with other existing programs for climatological and hydrological data handling (e.g. WMO's CLICOM and those available under the HOMS programme). Because RAISON software can be applied to other issues the Expert Group recommended that other applications requiring special adaptations of RAISON be negotiated between UN agencies and Canada on mutually agreeable terms.

Recommended Terms of Distribution:

1. **Distribution:** It is recommended that the RAISON/GEMS software should be distributed on an unlimited basis through the UN system in support of national and international programmes, subject to cost recovery conditions specified below. It is understood that Canada will, for its own purposes, distribute RAISON/GEMS and other RAISON software to any organizations in any countries without constraint. Appropriate records of distribution of RAISON/GEMS system software will be kept for the purpose of system maintenance.

2 **Cost:** It is recommended that Canada continue its policy of using an appropriate licensing fee to ensure RAISON/GEMS maintenance.

3. **Maintenance:** Canada expects that the RAISON/GEMS software package should remain stable for between one and five years and that the next major update will be undertaken by NWRI in approximately three years. Upgrades to the basic package will be issued from time to time and will be made available to RAISON/GEMS users at additional cost. In the event that the Canadian government decides not to support the RAISON development programme, it is recommended that suitable arrangements should be made to transfer the software to an appropriate agency to allow continued distribution of the software.

4. **Training:** It is recommended that distribution of the RAISON/GEMS software by UN agencies be accompanied by appropriate training in the use of the software. The training of users and the maintenance of the existing systems should be transferred, to the extent possible, to regional or national centres;

7. SUMMARY CONCLUSIONS

1. Taking into consideration the recommendations noted above, the experts consider that the RAISON/GEMS package is well suited for use in the GEMS/WATER programme for data processing and interpretation at the local, national and international levels and should be disseminated as soon as possible under the GEMS programme.

2. Because of the flexibility of RAISON/GEMS in multi-disciplinary environments, the package be considered by United Nations agencies as an integrating software framework for other types of data, for resource management issues within and beyond the water sector.

3. Specific recommendations were made for additions and improvements in system functionality that should be incorporated in future versions of RAISON/GEMS.

4. Recommendations on distribution of RAISON/GEMS within the GEMS programme included specific references to cost, maintenance, and training.

III. DIRECTION AND GOALS FOR FUTURE GEMS/WATER

DATA AND INFORMATION HANDLING

1. INSTITUTIONAL VIEWS AND ROLES

Presentations were made by the representatives of: the Global Runoff Data Centre (GRDC), the International Lake Environment Committee (ILEC), and the International Reference Centre (IRC) in the Hague, concerning various aspects of information storage, processing and dissemination.

1.1 Global Runoff Data Centre (GRDC), Germany

The representative of GRDC stated that knowledge of river discharge or stream flow is basic information that is required for all kinds of hydrological investigations and for the development and verification of global models of atmospheric circulation. This has led to the development of a databank of such information on a global scale, and maintained by the GRDC at Koblenz, Germany under the auspices of WMO. GRDC also participates in the GEMS/WATER programme by providing selected river discharge data. The GRDC data bank currently contains flow data from 2,930 stations from 131 countries. In order to enlarge the data base, efforts are also being made to enter flow data already available in published form, and from direct contacts with other institutes. Following the establishment of the World Climate Programme (WCP), the collection of flow data also became part of WCP-water, and is now being continued on a long-term basis.

The GRDC has developed a variety of programmes to provide users with a selection of retrieval options for daily and monthly flows, hydrographs of daily and monthly flows, flow duration curves and flow duration tables, station and catchment information, and the creation of data files. The representative of GRDC drew attention to the fact that the number of reporting countries has declined steadily since the early years of the Centre.

1.2 International Lake Environment Committee, Japan

The representative from ILEC pointed out that it is a non-governmental organization located in Shiga, Japan. The purpose of the organization is to promote the environmentally sound management of lakes and reservoirs in developing countries. It has a scientific committee composed of 19 renowned experts from 14 countries and includes the participation of UNEP. One of the major activities of ILEC is the implementation of a joint project with UNEP entitled "Survey of the State of the World's Lakes". The project, which was started in 1987, compiles natural and socio-economic data on the world's lakes and reservoirs, which are disseminated in a series of data books. So far three volumes of such books have been published containing information on 150 lakes around the world.

ILEC has been appointed as the supporting organization for a new UNEP "International Environmental Technology Centre" to be established in Shiga in the fall of 1992. The Centre will promote the environmentally sustainable management of freshwater lakes and reservoirs in developing countries, and countries with economies in transition.

1.3 International Reference Centre, The Hague

The representative of the IRC gave a brief description of the activities of the organization which had been established under the aegis of WHO in the context of the International Drinking Water Supply and Sanitation Decade. The purpose of the IRC is to collect and disseminate information on water supply and sanitation knowledge, rather than data, via leaflets, publications and training activities. He pointed out that the success of the programme was dependent upon its ability to develop focal points at the national level, and to enhance national capacity to deal with information. The experience of the Centre demonstrated that there was often a gap between the generators of information and the potential users, and that consequently there is a need to establish links between these two groups if the information is to be of any use. The task of public information requires the integration of users needs all the way down to the community level.

2. DEMONSTRATIONS OF DECISION-SUPPORT SOFTWARE PACKAGES

2.1 Catchment Management Support System - Dr. J.R. Davis, CSIRO, Australia

The Catchment Management Support System (CMSS) is an attempt to design a programme that makes it easier for policy makers to use scientific data. The purpose of the programme is to predict likely changes in nutrient loadings (Total-P, Total-N) to rivers within a river basin as a result of government policies. It is designed from a policy maker's rather than from a scientist's view of management needs. Thus it has some features which are unusual in models.

First, it has a database where each datum has a context associated with it. For example, the source and uncertainty of each datum are recorded with the data values.

The main interaction with the CMSS is through the policy module where policy developers can propose potential land use and land management changes in an English-like syntax. The syntax has been designed to allow a wide range of policies to be stated and stored away for analysis.

A simple nutrient balance model, using just two variables (the land use pattern and the nutrient generation rate), is used to predict current nutrient loads which can then be compared with gauging data. Then the policies are applied. The land use policies modify the land use pattern and the land management policies change the nutrient generation rates. The model can be rerun with these changes to calculate the nutrient loads after the policies have been implemented.

Finally, the policy developer can examine these predicted nutrient changes by asking the CMSS a number of questions about how the prediction was arrived at. In particular, the policy developer can ask which policies mainly influenced the change in nutrient load.

The system has been deliberately designed for data-poor, knowledge-poor river management authorities in Australia. It has simple hardware requirements (IBM-AT) as well as simple data requirements. Considerable emphasis has been put on calculating the reliability of predictions (because of the data scarcity) so that policy makers are advised on what predictions are trustworthy.

It has been applied to three drainage basins in Australia and funding is now available to produce a generic version for distribution to many basin agencies. A training programme is being developed and manuals will be produced as part of the overall package.

DISCUSSION: The choice of the combination of policies in the programme and the order in which they were presented in the simulations were based upon the perception of what was most important from the decision-makers' point of view. The positive and negative effects of decisions were aggregated to give an integrated result. The possibility of an apparently wise decision for nutrients having adverse effects for another water quality variable exists - the short time available meant that this could not be taken into account - in any event, policy decisions were often made without taking account of the implications for the full range of water quality variables. The model used loads as standards in this context - it might be possible to use concentrations in future developments. The possibility of presenting a single optimal solution to the policy-maker was raised but it was thought to be more effective to present a range of policy options with relative effectiveness and costs, which the policy-maker could then interrogate. A total investment of A$200,000 had been made over two years.

2.2 International Institute for Applied Systems Analysis (IIASA), Austria - Dr. K. Fedra

Software was presented which had been developed by IIASA and its various partners and clients, to deal with a wide range of information and decision-support systems customized for specific problems, regions and institutional users. These systems aim to integrate data bases, geographical information systems, simulation and optimization models, and experts systems within a unified graphical user interface and display system. These systems are based on Work Station technology.

Examples presented included surface and groundwater models, coastal marine water quality simulation, river pollution, expert systems for environmental impact assessment of water resources development projects, and climate change impact assessment system with a global environmental and climate data base. These systems are advanced model-based analysis and assessment systems, designed to support environmental planning, policy formulation and decision-making. Several of the features demonstrated in the IIASA software could be of interest for a subsequent phase of the GEMS programme.

2.3 United States Environmental Protection Agency, Athens GA. - Dr. T. Barnwell

It was noted that software can have a greater than expected lifetime and utility. The QUAL2 model was first developed in 1970 in the State of Texas, and its use is still growing. Consequently, it is wise to plan for a potentially extended life time of the software, for additions to the software, and for a wide distribution when developing general-purpose software. Such plans should make provisions for growth, but at the same time should clearly specify its limits, as the indiscriminate addition of capabilities can confuse the user, particularly in cases where these additions are designed to serve special purposes.

In designing software for a wide variety of applications it is best to take into account as wide a variety of computers as possible in order to anticipate problems. RAISON/GEMS developers may wish to examine the features included in the installation module used in QUAL2. That module tests the target machine to determine if it has the proper configuration in order to assist the installer and the supporting technician. The experience gathered in the EPA with the preparation of installation packages could benefit the development of the RAISON/GEMS system. He pointed out that a consistent user interface is difficult to develop and even harder to enforce, as programmers are tempted to use those with which they are familiar rather than those dictated by the specific needs at hand. The QUAL2 model was described, including its developmental history, application and features. QUAL2 is public domain software. Another software package that may have some application in the GEMS programme is the US Geological Survey's *Watershed Data Management System* called "*Annie-WDM*".

2.4 National Water Research Institute (NWRI), Canada. - Dr. D. Lam

An overview of the capabilities of the **advanced versions** of the **RAISON** software was presented. These offer enhanced mapping capabilities and the integration of satellite imagery as well as a variety of decision-support capabilities using artificial intelligence technologies. Mathematical models can be used in the RAISON platform either through reprogramming with RPL or simply in the original language of the model (e.g. FORTRAN). Explanations were given concerning the use of Expert Systems as part of the computer programme, including the use of existing geographical and database software by adding a set of rules obtained by interviewing specialists and experts in the area for which the computer will propose solutions. These rules are designed to guide the reasoning within the computer programme following predetermined paths. Examples were given in the operation of the system by using forward or backward chaining as well as backward tracking which are the main modes of operation of the system. This kind of software can be used, for instance, in the selection of a mathematical model best suited to a set of conditions. Applications have been developed for a variety of "upstream-downstream" management issues, large area policy development (as, for example, in acid rain sources/impacts), for selected public health concerns, and for groundwater taste and odour problems. Expert System technology as a decision-support tool for environmental management and policy development, is a principal area of research within NWRI's RAISON development programme.

IV. WATER DATA AND INFORMATION MANAGEMENT

1. CONCLUSIONS AND RECOMMENDATIONS

The purpose of the discussion was to examine the critical information, database and software requirements for achieving the GEMS/WATER goal of strengthening national capacities for water quality management, and to enable the preparation of comprehensive national, regional and global water quality assessments.

The Experts recognized the close relationship that exists between the needs for suitable monitoring at the country level and those of a Global Database. Consequently, the strengthening of national capabilities was considered to be essential. It was also agreed that the Global Database must offer some benefits to countries if their long-term participation in a reliable and consistent manner is to be ensured. At the same time, however, it was agreed that the Global Database does not need to rely exclusively on information made available through systematic monitoring at the country level, and that it should incorporate information available from other sources.

It was also recognized that a large amount of information is available in a number of databases, and that while it would not be possible or desirable to attempt to incorporate all this information into a single database, the establishment of suitable interfaces is essential. The issues to be assessed need to be clearly identified in order to define the scope and level of data to be accessed. It was also recognized that the preparation of water quality assessments incorporating analyses of causes and effects required access to information on a broad set of physical and socio-economic issues.

2. SPECIFIC RECOMMENDATIONS

1. **Scope of Application of the RAISON/GEMS Software:** The Expert Group felt that a typical set-up for implementation of the GEMS programme at the country level would involve the use of the basic RAISON/GEMS package at the regional/local or catchment level, as well as the central water authority level. In addition, the RPL version of the package could be made available to a technical or scientific institution acting as a national reference, training and maintenance centre.

2. **Auxiliary Data Needed by GEMS/WATER:** Given the inherent capacity of RAISON/GEMS to interface easily with other databases, it is important to take advantage of this facility in order to bring into the GEMS/WATER database relevant information available from other sources. In this regard, for instance, information included in WMO's referral system INFOHYDRO concerning water-related institutions needs to be included in the GEMS/WATER Global Database. In addition to monitoring data routinely included in the Global Database at NWRI, the Global Database would benefit from the incorporation of information from *selected parallel data bases* containing non-systematic water quality survey information and selected published data, especially from sources not easily obtainable but which can be accessed through the GEMS programme.

3. **Information Packages to GEMS/WATER Participants:** In order to strengthen the capacity of countries to collect and process information on water quality, the Expert Group recommends that GEMS/WATER should prepare a comprehensive country assistance package including:

* manuals with guidelines for water quality and quantity assessments,
* analytical quality assurance material,
* information on the RAISON/GEMS package oriented towards managers and potential users of the package,
* description of information that can be provided by GRID,
* information on water quality and related models that are available through international and national organizations such as the EPA as well as information on software and guidance material that is available through WMO's HOMS system,
* an example of the use of the RAISON/GEMS package in a country where it is being used, such as in Mexico.

4. **Promoting Progress in National Programmes:** The Expert Group recommends that the GEMS programme seek means to facilitate the flow of financing with a view to:

(a) organizing regional meetings aimed at establishing a network of professionals able to provide reliable and compatible data and information, amongst other, to the Global Database,

(b) implementing programmes for standard data entry capabilities at the national level,

(c) Providing a sound database at the national level for the formulation and implementation of sustainable national water quality programs.

The expert Group recognizes that the last issue is complex and has broad implications, some of them beyond the scope of the GEMS programme. This question should however be considered in view of its implications for data collection, interpretation and application at the national level.

5. **Need to Educate Managers in New Interpretive and Decision-Support Technologies:** The Expert Group recognized the need to sensitize water managers to the advantages of using information technology to enhance decision-making for specific environmental issues, and for policy development. Consequently, it recommended the organization of training workshops and seminars for officers dealing with water resources, including the management level.

6. **Access to Data:** The experts urge international and bilateral organizations to ensure that the data generated through their technical cooperation programmes be made available to the international community.

7. **Need for Progress in Integrated Water Management Information and Information Technologies:** The International Conference on Water and the Environment, held in Dublin in January 1992, stressed the need for integrated management of water resources. The preparatory process for UNCED has also highlighted the importance of information management. The Expert Group urges United Nations technical agencies, through the ACC Intersecretariat Group for Water Resources, to address the broader issue of information management and information systems, and their application to sustainable development of water resources at the national and global scales. In this regard, the role of existing and future programmes, such as GEMS/WATER, CESI, WASAMS, GRID, HOMS, GCOS, CLICOM, IHP and others must be taken into consideration.

8. **Lead Role for GEMS/WATER in Information Technologies:** The Expert Group recommended that GEMS/WATER play a lead role in the application of advanced information technology to the integration of water quality and related information, both for national water quality programmes and for global network purposes. This requires the examination of types of data sets needed, technical questions concerning access, storage and retrieval, and the development of appropriate decision-support software for national decision-making and global assessment.

GLOSSARY

ACRONYMS

Institutions

CSIRO	Commonwealth Scientific and Industrial Research Organization, Australia.
GRDC	Global Runoff Data Centre, Koblenz, Germany.
GRID	Global Resource Information Database.
IIASA	International Institute for Applied Systems Analysis, Austria.
ILEC	International Lake Environment Committee, Shiga, Japan.
IMTA	Instituto Mexicano de Tecnologia del Agua.
INCYTH	Instituto Nacional de Ciencia y Tecnica Hidricas, Buenos Aires, Argentina.
IRC	International Reference Centre. - International Water & Sanitation Centre, Hague
NWRI	National Water Research Institute,(Environment Canada).
MARC	UNEP's Monitoring and Assessment Research Centre, London, U.K.
UNCED	United Nations Conference on Environment and Development.
UNEP	United Nations Environment Programme.
UNESCO	United Nations Educational, Scientific and Cultural Organization.
UNITAR	United Nations Institute for Training and Research.
US-EPA	United States Environmental Protection Agency.
WHO	World Health Organization.
WMO	World Meteorological Organization.

Technical Acronyms

CLICOM	Climate Data Management System (WMO)
GEMS	Global Environment Monitoring System.
GCOS	Global Climate Observing System.
GIS	Geographical Information System.
HOMS	Hydrological Operational Multi-purpose Sub-programme.
IDRISI	A grid based geographic analysis system.
IHP	International Hydrological Programme (UNESCO).
INFOHYDRO	WMO information system on water-related institutions.
QUAL2	a US-EPA Water Quality Model.
RAISON	**R**egional **A**nalysis by **I**ntelligent **S**ystems **ON** a microcomputer.
WASAMS	Water and Sanitation Monitoring System.
WCP	World Climate Programme.

GEMS/WATER

RAISON/GEMS Software Expert Review Meeting

North/South Seminar Room
National Water Research Institute (NWRI)
Canada Centre for Inland Waters
Burlington, Ontario
May 11-15, 1992

PART 1: Review of the RAISON/GEMS Software

Day 1: Monday, May 11

8:45	-	9:40	**Official Opening** Dr. R.J. Daley, Executive Director, NWRI Dr. V. Vandeweerd, United Nations Environment Programme - selection of chairpersons and rapporteurs	
9:40	-	10:45	**Introduction to GEMS/WATER** * overview, objectives, mode of operations * National participation: a participating country perspective (Argentina)	(Helmer) (Natales)
Coffee				
11:00	-	12:30	**RAISON/GEMS** * Evaluation Criteria * Background to RAISON * Technical Overview	(Vandeweerd) (Ongley) (Lam)
LUNCH --- CCIW Cafeteria				
			RAISON/GEMS - continued>	
1:30	-	2:30	* Spreadsheet * Statistics	(Fraser) (Lam)
Coffee				
3:15	-	3:45	* Database	(Fraser)
3:45	-	5:30	* Hands-on/informal discussion	

Day 2: Tuesday, May 12

RAISON/GEMS - continued.

8:30	-	9:30	* Datamapping	(Lam)
9:30	-	10:45	* Maps	(Swayne)

Coffee

11:00	-	12:30	* Hands-on	

LUNCH -- CCIW Cafeteria

RAISON/GEMS - continued

1:30	-	2:00	* Contour Overlay	(Lam)
2:00	-	2:30	* Lakes Graphs	(Fraser)
2:30	-	5:00	Hands-on/informal discussions	

Day 3: Wednesday, May 13

RAISON/GEMS - continued

8:30	-	9:30	* Observations by participating countries	
			- China Training	(Tsu)
			- Mexico Applications	(Leon)
9:30	-	10:30	* General Discussion on RAISON/GEMS	

Coffee

10:45	-	12:20	* General Discussion and Conclusions	

LUNCH -- CCIW Cafeteria

Part 2: Direction and Goals for Future GEMS/WATER Data & Information Handling

The purpose of the second part of this meeting is to determine the critical information, database and software requirements that are necessary to achieve the GEMS/WATER goals of (1) strengthening national capacities for water quality management and (2) comprehensive water quality assessments by the year 2005.

Examples of Advanced Information and Evaluation Systems

1:15	-	1:55	* IIASA	(Fedra)
1:55	-	2:35	* US-EPA	(Barnwell)

Day 3 - continued

Coffee

2:55	-	3:40	* Environment Canada (NWRI)	(Lam)
3:40	-	4:15	* CSIRO	(Davis)
4:15	-	Bus to Hotel		
4:45	-	Bus to NIAGARA PENINSULA AND NIAGARA FALLS		
7:30	-	Dinner at Niagara Falls		
10:00	-	Return to Burlington		

Day 4: Thursday, May 14

PART 2 -- Continued

8:30 - 10:30 * Discussion on the potential of information handling software (such as those demonstrated) to support integrated GEMS/Water quality assessments, and national/basin water quality management, including discussion on methods to ensure the efficient integration of relevant data and expertise such as:

- geo-referenced data
- non-water quality data and information (e.g. hydrology, meteorology, demography, land use, etc.)
- capture of expertise where data are lacking
- setting goals for the year 2005

Coffee

10:45 - 12:30 * Discussion on water quality data handling systems and software for improvement of the GEMS/Water global monitoring programme over the long-term:

- GEMS/Water data handling at the national level
- water quality data transfer
- global data base operations
- goals for the year 2005

LUNCH -- CCIW Cafeteria

1:30 - 4:00 * Proposals for short-term improvements to the GEMS/Water data handling and assessment operations, including:

- improvements to current GEMS/Water data handling activities
- improvements to RAISON/GEMS software
- alternative data sets (e.g. survey data)
- integration with other data sets
    * ILEC lake information (descriptive, quantitative)
    * WMO's Global Runoff Data Centre (GRDC)

Day 4 - continued

(Coffee available at 3:00)

4:00	-	5:00	* Formulation and discussion of major recommendations
7:30	-	10:00	* Compilation of draft report by rapporteurs

Day 5: Friday, May 15

8:30	-	10:00	* Meeting of Rapporteurs
8:30	-	10:30	* GEMS/Water Steering Committee (Representatives from: UNEP, WHO, WMO, UNESCO, NWRI, ILEC, GRDC)
9:30	-	10:00	Tour of CCIW (begin in North/South Seminar Room)

10:00 -- Coffee

10:30	-	12:15	Presentation and acceptance of Draft Report
12:15	-	12:30	Adjourn Meeting.

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